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E L E M E N T S
OF THE
ART OF DYEING.

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TRANSLATED FROM THE FRENCH

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VOL. I.

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TRANSLATOR's PREFACE.

THAT translations of the works of eminent foreign writers are of great utility to science and the arts is a truth which has long been known and acknowledged, and indeed so rapid is the progress of improvement in modern times, that such translations are every day becoming more important: an ardent spirit of inquiry having pervaded the greater part of Europe: and almost every nation in this quarter of the globe, having given birth to men of superior talents and industry, who are deeply engaged in exploring the operations of nature.

It is evident, that every country must be much benefited, which by means of early translations, possesses itself of the fruits of

the labours of foreign nations. It collects as it were into a focus, the scattered lights which are struck out in different parts of the world, and thus reaps an immediate advantage from discoveries which had a distant origin. Although the Philosophers of our own country have been eminently distinguished by that zeal for the advancement of science, which is one of the characteristic features of the present age, yet it must be acknowledged that in the application of scientific chemistry to the arts, we have been surpassed by our neighbours on the continent. The principles of the art of dyeing in particular, seem to have been neglected by us, or at least do not appear to have obtained that degree of attention to which they were entitled, from their importance both to the manufacturer and the man of science.

No systematic treatise on this subject has hitherto appeared in our language, excepting a translation of Hellot, with which
the

the public are very little acquainted. It is true, we meet with some very ingenious and scientific remarks on dyeing, in Lewis's *Commercium Philosophico Technicum*; but these are confined almost solely to the black dye. We have likewise some valuable observations on this subject, in the translation of Macquer's *Chemical Dictionary*. These works, together with a few books of receipts taken from Hellot, d'Apligny, Macquer, and Dufay, comprehend almost every thing I have yet seen in the english language on the art of dyeing.

The intelligent reader will perceive that in the present work, much light is thrown on the principles of the art of dyeing by the late improvements in chemistry. From an attentive perusal it will appear, that by means of the properties of the different gases, by an attention to the influence of light and to complicated chemical combinations, the ingenious author

has been enabled successfully to explain many important facts, the causes of which were formerly involved in obscurity. Considered in this point of view, it is conceived, that the work which I have undertaken to translate will be highly acceptable to the philosophical chemist; but it is to the manufacturer that this work is principally addressed. He will find in it methods of conducting his processes equally new and simple. He will learn from it to ascertain with greater certainty the success of his operations; it will furnish him with an opportunity of comparing his own processes with those of other artists, and of adopting the improvements derived from the labour and ingenuity of his predecessors and contemporaries.

In this treatise particularly, he will find a certain mode of determining the qualities of the materials he employs, which will enable him to proportion the quantities so accurately to each other as to
avoid

avoid all waste, and direct him to the value of any article of which he can procure a sample. This improvement principally depends on the use of the acids, and more especially of those which have been termed oxygenated.

With a view to facilitate the mode of obtaining the acids, I have ventured to add a description and drawing of an apparatus for the distillation of those substances, which from experience I find more simple and advantageous than any that I have yet seen.

Respect for the author has induced me to retain the new french nomenclature, which is at present becoming fashionable; although it might have been more acceptable to many of my readers, if I had substituted the terms in common use, for those that have been employed by Mr. Berthollet. With a view, however, to prevent any mistakes that might arise from
this

this source, I have subjoined a vocabulary, and have likewise added an index, without which no important work should appear.

In a few instances, I have endeavoured to illustrate the observations of our author by notes. These are not so copious or numerous as I could have wished, but I was solicitous to make my countrymen acquainted with this valuable work as early as possible, and certain circumstances, with which it is unnecessary to trouble the reader, have obliged me to finish the translation within a limited time.

I shall only add that in translating a philosophical work, which consists chiefly of a detail of important facts and inferences, I have deemed it right to prefer perspicuity to elegance.

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INTRODUCTION.

A STRONG desire of attracting attention is observable in man in his most uncultivated state. Amongst the means of gratifying this desire, the beauty of brilliant colours naturally presents itself. Thus even savage nations paint their skins, and adorn themselves with feathers, stones, and shells of lively hue.

The women of Gaul on their festival days used to stain themselves of a brown olive colour with woad, and this no doubt exercised the vanity of those of higher rank.

The origin of the art of dyeing is certainly therefore of great antiquity, and very possibly nations, little civilized, where nature had furnished colouring materials of easy application, might possess species of tints which polished nations may have highly esteemed: thus the Gauls prepared some colours which even the Romans did not despise. The art however

must have waited the progress of industry and luxury, to be much extended or improved.

The Egyptians, according to Pliny ^a, had discovered a mode of dyeing, somewhat resembling that which we use for colouring printed linens; the stuffs, probably after having been impregnated with different mordants ^b, were immersed in vats, where they received various colours. It is to be presumed however, that the industry of a people, whom sacerdotal power, by express laws, forbade to change even their most indifferent customs, could not be very active.

When we wish to estimate the progress of the human mind in remote times, we turn our attention to Greece; but there we find a striking difference between the fine arts, and those subservient to our convenience or luxury; a difference, the cause of which, may be perceived. Public opinion placed those arts at an immense distance from each other; for while glory was attached to the former, the

^a Hist. Nat. lib. xxxv. chap. 2.

^b It does not appear that the English artists have any term appropriated to this class of bodies composed chiefly of earthy and metallic salts, employed in the preparation of stuffs, to fit them for the reception of more durable colours, I have therefore thought it best to retain the original word. T.

latter were confounded with disgraceful and servile employments.

The distinction however was in part well founded. The painter, the statuary, the architect, stamped their genius on their productions; their art did not require long continued efforts for its increase, nor the accidents and experiments of ages for its slow improvement. Their invention was able at once to pass the limits of time, and those master pieces of art, which so rapidly succeeded each other in Greece, have justly become the admiration of posterity.

Yet this nation however fruitful in genius, or productive of great men, suffered itself to be led away by its inclinations, and bestowed its esteem too partially. For while crowns and the most splendid honours were decreed to those who excelled in wrestling, boxing, and running, the useful arts were degraded, even in the eyes of philosophers.

This is one of the most striking characters by which the philosophy of the ancients is distinguished from that of the moderns. The ancients were chiefly engaged in speculations, which might procure them the respect of a people, who, while they dispensed glory, thought the useful arts unworthy their attention.

This contempt descended to the Romans; for Pliny speaking of dyeing, avowedly neglects the description of operations which are unconnected with the liberal arts; *nec tingendi rationem omiffissimus, si unquam ea liberalium artium fuisset.*

Modern philosophers, above the vulgar, yet despised by the great (whose pride is supported by pretensions wholly foreign to human science) have given themselves up to cold calculation, and to the humble description of what nature and art present to them. They have traced the connexion of the numberless wonders that have occurred to them, and have discovered in the labours of industry, as well as in commerce, the source of national prosperity, the seeds of extensive population, and the grand support of agriculture. But it was the academy of sciences of Paris which first attempted to shed the light of science upon all the arts, which formed the project of publishing the description of them, and which in the midst of prohibitory regulations, formed the elevated idea, that the industry of a nation cannot fail to be enlightened and increased by a free communication of all the processes it uses, and that the sacrifices it makes by this publicity, are amply compensated by the advantages it derives from it.

This

This plan was extended to all the objects of knowledge by the Encyclopædia, the most magnificent monument ever raised to philosophy and reason.

The art of dyeing among the Greeks could have had but little assistance from science; but the activity of genius is communicative, and industry multiplies its efforts when solicited by luxury. Let us see then what progress luxury had made in Greece. Let us consult the philosophical picture which has been lately drawn of its manners.

A number of the citizens of Athens passed their time in the different tribunals, for which they received three oboli, that is nine sous per day (about 4½d. Eng.) The medium price of a septier (twelve bushels) of corn, which is the most natural standard of comparison, was thirteen livres (10s. 10d. Eng.); that is a little more than half the medium price with us; so that a citizen of Athens with the daily pay he received for the discharge of the most important duties of the republic, might purchase a measure of corn, the price of which at present is fifteen sous (7½d. Eng.) In order then to form an idea, not of the public magnificence, nor of that of some individuals, but of the ease and luxury of the ordinary class of citizens,

we must consider, what they would be at Paris, if the salary of the public offices was fifteen sous per day.

“ Many of them (the Athenians) went bare-footed. The dress of the people was made of cloth which had received no dye, and which might be washed (*reblanchir*). The rich preferred coloured cloths^c; they esteemed such as were dyed scarlet by means of certain grains of a reddish colour; but they valued still more highly those of a purple dye.”

Silk, which is subjected to the greatest variety of the processes in dyeing, comes originally from China. The annals of that nation inform us, that the wife of the emperor Hoang Ti, was the first who spun threads from the natural silk cocoons, found on the trees. From this country, silk was carried into Indostan, and thence to Persia, Greece, and Rome, where however it was not known till a very considerable time after the first employment of it. Some have concluded from a line in Virgil's *Georgics*^d, that it was in use at Rome in the time of Augustus. What Pliny says on the

^c Voyage du jeune Anacharsis.

^d Velleraque ut foliis depectant tenuia Seres *Georg.* lib. ii.

subject is less ambiguous. In the reign of the emperor Justinian,^e silk still bore so high a price that it sold for its weight of gold^f. It was about this time, that silk worms eggs were brought by certain monks, from India to Constantinople, where a method of hatching them, and of spinning from their cocoons was discovered^g. Silk worms seem to have been first introduced into Italy about the time of the Crusades.

The art of dyeing linen appears not to have been known in Greece before Alexander's invasion of India, where, according to Pliny, they dyed the sails of his vessels of different colours. The Greeks seem to have borrowed this art from the Indians.

India was the nursery of the arts and sciences, which were afterwards spread and perfected among other nations. Accidents which had a tendency to improve the art, could not fail to be multiplied rapidly, in a country rich in natural productions, which requires little labour for the support of its inhabitants, and the population of which was favoured by the bounty of nature, and the simplicity of man-

^e Voltaire, *Essai sur les Mœurs*, &c.

^f Procop. lib. iv. cap. 17. de bello Gothico.

ners, till it was opposed by the tyranny of succeeding conquerors. But religious prejudices and the unalterable division in casts, soon put shackles upon industry ; the arts became stationary ; and it would seem that the knowledge of dyeing cotton in that country (for silk was then unknown, or at least very scarce) was as far advanced in the time of Alexander, as it is at present.

The beautiful colours which we observe in those Indian linens, to which we used to give the name of *Perfes*, because they came to us from Persia, would lead us to think that the art of dyeing had there attained a high degree of perfection ; but we find by the description which Beaulieu gave (at the request of Dufay) of some operations performed under his own eye^s, that the Indian processes are so complicated, tedious, and imperfect, that they would be impracticable in any other country, on account of the difference of the price of labour.

European industry has far surpassed them in correctness of design, variety of shade, and facility of execution, and if we are inferior to them with respect to the liveliness of two or

^s *Traité sur les toiles peintes dans lequel on voit la maniere dont on les fabrique aux Indes & en Europe.*

three colours, it is only to be attributed to the superior quality of some of their dyes, or perhaps to the length and multiplicity of their operations.

We may then conclude, that the art of dyeing was much more limited, and less perfect, among the ancients than among the moderns ; but they were in possession of one species of dye, which has been either lost or neglected, which was an object of the most refined luxury ; that is, purple : its processes have more attracted the attention of philosophers, and been more carefully preserved in historical records, than those of any other colour.

I shall pass over the fables with which they have endeavoured to embellish the origin of the purple dye ; but it is probable, that it was discovered at Tyre, and contributed much to the opulence of that celebrated city.

The liquor used in dyeing purple was obtained from two kinds of shell fish, the larger of which was called the purple, the other was a species of whelk : they were each subdivided into many varieties, and were still further distinguished, as they afforded a more or less beautiful colour, according to the coast where they were taken, &c.

The

The colouring liquor for purple is found in the throat of the fish, in each of which was contained only a single drop; they used to bruise the whelks, which likewise contained a very small quantity of a red liquor with a black tinge (*nigricantis rosæ. Plin.*)

When they had obtained a certain quantity of the colouring liquor, they mixed with it a proportion of common salt; they macerated them together for three days, and then added five times the quantity of water; this mixture they kept in a moderate degree of heat, and separated, from time to time, the animal parts which rose to the surface; these operations lasted ten days, after which they ascertained with a piece of white wool, whether the liquor had acquired the proper shade.

The stuff was prepared for receiving the dye in various ways; some immersed it in lime water, some prepared it with a kind of *fucus*, which served, like some of our mordants, to render the colour more fixed (*solide*).

We do not know precisely the marine plant to which the ancients gave the name *fucus*, but its use was so extensive in dyeing, that the word became a generic term, including all sorts of colouring substances. Mr. le Pileur d'Apligny conjectures that it might be a kind
of

of archil, which is found on the coast of Candia^b; others again prepared their cloth with alkanet.

The liquor of the whelk alone did not afford a durable colour, but it increased the brightness of that obtained from the other kind of shell fish. The Tyrian purple was prepared by two operations, a first dye was communicated by the liquor of the purple, and a second by that of the whelk, hence it was called by Pliny *purpura dibapha*. In other processes they employed a mixture of the liquor of both the shell fish; for instance, for 50 lb. of wool, they used 200 lb. of the liquor of the whelk, and 100 lb. of that of the purple fish; thus they obtained an amethyst colour; sometimes they gave a ground with *coccus*, which is our kermes, and then dyed with the liquor of the purple fish; in fine, by different combinations of the above methods they obtained a great variety of purples, which they distinguished by different names; the Tyrian purple, according to Pliny, was of the colour of coagulated blood; the amethyst purple had that of the stone, so called; another kind more resembled the colour of the violet, &c. &c.ⁱ

It

^b Essai sur les moyens de perfectionner l'art de la teinture.

ⁱ Those who wish for further information respecting the purple

It appears that some of the kinds of purple preserved their colour for a very long time; for Plutarch in his life of Alexander relates, that the Greeks found in the treasury of the king of Persia a great quantity of purple, which had not lost its beauty though it was one hundred and ninety years old.

The very small quantity of liquor obtained from each shell fish, and the tedious process of the dyeing, raised the price of purple so high, that in the time of Augustus a pound of wool of the Tyrian purple dye, could not be purchased for one thousand denarii, about seven hundred livres of our money (£29 11s. 8d. Eng.)

Priests, who have always sought to derive advantages from whatever could make impression on the multitude, attributed in former times a sacred character to purple. It was a colour pleasing to the divinity, and was to be appropriated to his worship, and although the use of it has been long discontinued, the pride

purple of the ancients, may consult the following modern works. Fabii Colomne *Lyncæy purpura*; G. Gottlob Richter *progr. de purpura antiquo & novo pigmento*; Reaumur *mem. de l'acad.* 1711; and above all a learned work of Mr. Bischoff, entitled *Versuche einer geschichte der faberkunst*, &c. 1780.

of the name is still preserved in our sacerdotal hierarchy.

The purple has been, almost every where, a mark of distinction attached to high birth and dignities. It was an ornament of the first offices of Rome ; but luxury, which was carried to great excess in that capital of the world, rendered the use of it common among the opulent, till the emperors reserved to themselves the right of wearing it : soon afterwards, it became the symbol of their inauguration.

They appointed officers to superintend the manufactories, principally established in Phenicia, where it was prepared solely for their use. The punishment of death was decreed against all who should have the audacity to wear it, though covered with another colour.

The penalty so tyrannically denounced against this whimsical species of treason, doubtless occasioned the loss of the art of dyeing purple ; first in the West, but much later in the East, where it flourished considerably till the eleventh century.

The ancients obtained from the *coccus*, now known by the name of kermes, an account of which is given (Secd. III. Part II.) a colour which was almost as highly esteemed as the
3 purple,

purple, and which was sometimes mixed with it, as we have before remarked. Pliny informs us, that it was employed in the preparation of the imperial robes. It was generally called scarlet, but sometimes it was confounded with the purple.

It appears, that it was not till the time of Alexander and his successors, that the Greeks attempted materially to improve the black, blue, yellow, and green dyes.

Among the Romans it was customary from the earliest times, for newly married women to wear a yellow veil, and this colour was appropriated to matrons.

In the games of the circus there was a kind of quadrill ^k, the divisions of which were distinguished by the colours, green, *color prasinus*, orange, *rufatus*, ash coloured, *venetus* ^l, and the white.

^k This term denotes a troop of cavaliers pompously dressed and mounted for the performance of certain games, &c. It is borrowed from the French quadrille, or squadrille, and that probably from the Italian quadriglia. They were never composed of less than four divisions, nor of more than twelve, and each division consisted of twelve cavaliers at most, and at least of three. T.

^l This, rendered in the original by *le cendré*, is also, and I believe more commonly, used to denote a light blue, or sky blue. T.

We

We are enabled to judge of the qualities of these colours by the substances used in making them. I shall enumerate after Mr. Biscoff, who has minutely examined the subject, the ingredients employed at that time, in the art of dyeing, in addition to the coccus and the purple shell fish.

1. Alum. It seems probable from what is observed in the first part of this work (Sect. III.) that the ancients were unacquainted with our alum in its state of purity.

2. Alkanet. Suidas says, that this substance was also used by women as a paint.

3. The blood of birds, which was used among the Jews.

4. The fucus. That of Crete was preferred, and it was generally employed as a ground for valuable colours.

5. Broom.

6. The violet; from which the Gauls prepared a colour which resembled one kind of purple.

7. *Lotos medicago arborea*. Snail trefoil (luzerne en arbre). The bark was used in dyeing skins, and the root in dyeing wool.

8. The bark of the walnut-tree, and the peel of the shell.

9. Madder.

9. Madder. We do not know whether the madder plant of the ancients was the same as ours, or whether it was another root of the same tribe.

10. Woad. (glastum). This plant was undoubtedly in use among the ancients, but we do not know whether their preparation of it was the same as ours.

Although the ancients might have employed some substances, of which we have no account, we easily perceive that our acquisitions, more especially since the discovery of America, give us a decided superiority in many colours. With respect to the regret which has been often felt for the loss of the art of dyeing the celebrated purple, it may be questioned whether it is well founded, and whether we are not able to produce a purple equally beautiful?

The shell fish which furnished the purple dye, probably exist now, in as great abundance as formerly. They have been so accurately described that they may be recognized; and in fact, Thomas Gage informs us, that shell fish have been found near Nicoya, a small Spanish town in South-America, which possess all the properties described by Pliny, and others of the ancients. These shell fish it appears, are

at present used in dyeing cotton, on the coasts of Guaguaquil and Guatimala ^m.

Cole, in the year 1686, discovered some of them on the English coast, and Plumier found a species of them at the Antilles. Reaumur has made many experiments on the whelks, which he obtained from the coasts of Poitou, and Duhamel has minutely examined the colouring liquor of the purple shell fish, which he found in great abundance on the coast of Provence. He observed, that this liquor does not take a purple colour without the action of light, a circumstance which Reaumur had before remarked respecting that of the whelk; that though at first white, it becomes of a yellowish green, which deepens to a sort of blue, that it afterwards reddens, and in less than five minutes becomes of a very fine deep purple ⁿ, now the purple of the ancients possessed these characters.

Further, we have a very minute description of the manner of catching the shell fish which produced the purple, by an eye witness, Eudocia Macrembolitissa, daughter of the emperor

^m Hist. philosoph. & polit. du comm. des Indes. liv. vi.

ⁿ Mem. de l'Acad. 1736.

Constantine the eighth, who lived in the eleventh century °.

Our indifference as to procuring the purple, and our negligence of the experiments of some modern philosophers respecting it, arise, I think, from our being already in possession of more beautiful, as well as much less expensive colours; and I am not singular in this opinion ^p. In fact, the kermes affords a colour which was almost as highly esteemed by the ancients, as the purple, and contributed to that which they distinguished by the name *Color Hyfginus*. Now we know how to employ the kermes probably to greater advantage than they did, because we possess a pure alum, which prepares the stuff to receive a more beautiful and durable colour; yet our dyers have been induced almost entirely to discontinue the use of it, because they can obtain from cochineal a colour beyond all comparison more beautiful.

° Eudocia Macrembolitissa was married to one of the Constantines, and after his death to Rom. III. who was made emperor in 1068. The work is to be found in a collection published by Mr. d'Anse de Villoison, under the title of *Anecdota græca e regia Parisensi & e veneta S. Marci bibliothecis deprompta*. T. i. 1781.

^p Bischoff versuche, &c. Gouget de l'origine des loix, des arts, & des sciences, 2^e partie, liv. ii.

If we suppose that the slight difference observable between the colour obtained from the kermes, and that of the Tyrian purple, is compensated by the advantage we derive from the employment of our alum, we may consider this admired purple, which on pain of death, none but the Cæsars could wear, as similar to that blood red we see in old tapestry, which was produced by kermes.

The supposition that the colour which we obtain from the kermes, is preferable to that obtained from it by the ancients, is supported by the testimony of Pliny, who insinuates that it was not a durable colour; now the colour we give by means of kermes, to wool prepared with alum, is exceedingly durable.

The ancients were not acquainted with that useful substance soap*, which must give us a superiority in scouring, and some parts of the art of dyeing. Instead of it, with a view to get grease out of wool, and to wash linen, they made use of a plant, called by Pliny *radicula*, and by the Greeks *struthion*, and which some think was our *saponaria*, soap-wort; they likewise employed with the same view, another plant, which Pliny describes as a species of poppy. Homer represents the princess Nausica

* Goguet, *ibid.* part. i. liv. ii.

and her attendants washing their linen clothes in the ditches, by trampling on them with their feet. We are informed by other authority, that the ancients used ashes in washing; and some of the bolar earths were likewise employed for that purpose.

From the new world, we have acquired several substances that have been found useful in dyeing, namely cochineal, brasil wood, logwood, and anotta.

But above all, we are indebted for the superiority of our colours to our preparation of alum, and the solution of tin, which give so much brilliancy to many of our dyes. Our very general use of silk, which takes such lively and beautiful colours; the rapid intercourse of trade, which brings the luxury of China and the Indies within the reach, even of the vulgar; the activity of industry, enlightened and stimulated by jealousy, and a contention for superiority among the different nations of Europe; these circumstances have raised us very much above the ancients, and have made colours common among us, with which the most opulent among them, were unacquainted: but previous to the acquisition of this superiority, Europe experienced all the devastations of barbarism.

In the fifth century, all the arts were lost throughout the West; except a few, which in a state of decay, were preserved in Italy; and no traces were left of knowledge, industry, or humanity.

Muratori ^a quotes a manuscript of the eighth century, in which we find a description of some dyes, principally for skins, and some processes connected with other arts; but the Latin, which is almost unintelligible, and the chasms we find here and there, prevent us from being able to form a just idea of these processes ¹.

The arts were better preserved in the East, where articles of luxury were procured by some of the great, even so late as the twelfth century.

During the crusades, the Venetians derived their power from the barbarous mania of the

^a Diff. de textrina & vestibus sæculor. rudium. *Antiq. Ital.* vol. ii.

¹ I shall quote literally a description of alum, which seems to prove that they employed only aluminous stalactites, or a volcanic earth impregnated with alum.

DE ALUMEN.

Alumen autem metallum, est terra floriens de Eritarin. Eritarin terra est alba facilis ad pisandum.

age; their fleets were loaded with provisions for our destructive emigration; their commerce increased, the arts were established among them, and improved by the industry of the Greeks, and spread from thence through the other parts of Italy. In the year 1338, Florence contained two hundred manufacturers, who are said to have made from seventy to eighty thousand pieces of cloth, which, as an object of commerce, was worth twelve hundred thousand crowns of gold.

It is said, that archil was accidentally discovered by a Florentine merchant, about the year 1300. Having observed that urine imparted a very fine colour to a certain species of moss, he made experiments, and learned to prepare archil.

He kept his discovery secret for a long time; his posterity, a branch of which still exists, according to Dominique Manni, have retained the appellation *Ruccellai*, from *Oreiglia*, the Spanish term for that kind of moss.

The arts continued for a long time to be cultivated in Italy with increasing success. In the year 1429, the first collection of the processes employed in dyeing, appeared at Venice, under the name *Mariccola del' arte de i tenteri*: a second edition of it, much improved, came

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out in 1510. A certain person called *Giovan Ventura Rosetti*, formed the design of rendering this description more useful and extensive. He travelled through the different parts of Italy and the neighbouring countries, where the arts had begun again to flourish, in order to make himself acquainted with the various processes employed; and he published under the title *Plictho*, a collection, which according to Mr. Bischoff, is the first that united the different processes, and which ought to be regarded as the leading step toward the perfection which the art of dyeing has attained^s.

It is remarkable that in the work entitled *Plictho*, not a word is said either of cochineal or of indigo, probably these two dyes were not employed in Italy.

Pliny, indeed, speaks of a substance which came from India, which he calls *Indicum*, but

^s *Plictho de l'arte de tentori, che insegna tenger panni, tele baubasi & sede, si per l'arte maggiore, come per la commune vinczia, 1548.*

This work has been translated into French, under the title of *Suite du teinturier parfait, ou l'art de teindre les laines, soies, fils, peaux, poils, plumes, &c. comme il se pratique a Venise, Genes, Florence, & dans tout le Levant, & la maniere de passoz en chamois tout sorte de peaux, traduit de l'Italien, Paris 1716.*

it was only used in painting. It is very probable however, that the Indians employed it in dyeing. The first of it used in Europe, appears to have been brought to us from the East-Indies, by the Dutch. The cultivation of it in America, was first established at Mexico, and afterwards in other parts, where it acquired a quality superior to that which we still get from India.

For a long time, Italy, and especially Venice, possessed the art of dyeing almost exclusively; a circumstance which contributed to the prosperity of their manufactories and commerce: by degrees it was introduced into France. Giles Gobelin, to whom the process for making the true scarlet had been communicated, established a manufactory in the place, which still bears his name. This undertaking was deemed so rash, that it was termed *Gobelin's folly*; but his astonishing success, at length induced our ancestors to think he had made a compact with the devil. The discovery of scarlet may be considered as the most remarkable era in the art of dyeing. The ancients, as we have seen, applied the name scarlet to the colour obtained from kermes, which was much inferior in beauty to the colour we distinguish by that appellation.

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The Spaniards having observed that the inhabitants of Mexico employed cochineal in painting their houses, and dyeing their cotton, gave their government an account of the beauty of that colour; and Cortes, in the year 1523, was ordered to promote the increase of the valuable insect, from which it is obtained: the natural colour however, which the cochineal gives, is but a dull crimson.

Soon after cochineal was known in Europe, a great chemist, of the name of *Kuster*, *Kuffler*, or *Kepfler*, found out the present process for making scarlet, by means of a solution of tin, and carried the secret to London in the year 1643.

A Flemish painter called *Kloeck* or *Gluck*, got possession of this secret, and communicated it to Gobelin. The knowledge of the process, afterwards spread throughout all Europe. Gluck travelled into the East, where there were still some remains of Grecian industry, and afterwards settled in Flanders, where he spent a long and prosperous life. According to Mr. Francheville, this man who had been so useful to his country, died about the year 1550¹.

¹ Mem. de Berlin, 1767.

The use of indigo, which was likewise a great acquisition to the art of dyeing, was not so easily established as that of cochineal; it was strictly prohibited in England, in the reign of Elizabeth, as was also logwood, which was ordered to be burned if found in any manufactory; this prohibition was not taken off till the reign of Charles the second.

In like manner the use of indigo was proscribed in Saxony; in the edict against it (which brings to one's mind the edict against the employment of antimonial emetics) it is spoken of as a corrosive colour, and called food for the devil, *Fressende Teufels* *.

This is a striking example of the errors into which an unenlightened administration may fall, which listens to the suggestions of interested individuals.

Those who dyed blue, and were accustomed to use pastel and woad, represented, that indigo would destroy the sale of these two articles, which were the produce of the country. Such a reason, which would appear specious to many even in the present day, easily produced a prohibition, which would be soon eluded by paying a tribute to the industry of other na-

* Bischoff versuche, &c.

tions. The prejudice against indigo was likewise communicated to France, and Colbert's instruction forbade the use of more than a certain quantity in the pastel vats.

The industry of France, which had remained in a languid state during the stormy administration of Richlieu and Mazarin, received a support from Colbert, which soon raised it to preeminence among the nations of Europe; he invited the most skilful artists, he rewarded their talents, and established many manufactories; and it is curious to remark, that those of Vanrobais and Sedan were called in the letters patent which were granted them, manufactories of fine cloth, after the Dutch and English fashion. In the year 1672, he published a table of instructions for dyeing^w, which merits attention.

The legislator first presents us with the reasons that should induce us to think the object he is considering, an object of consequence;

^w General instruction for dyeing wool, and woollen manufactures of all colours, and for the culture of the drugs or ingredients employed in them. This work was reprinted in 1708, under the following title. *Le Teinturier parfait, ou instruction nouvelle et generale pour la teinture des laines et manufactures de laine de toutes couleurs, et pour la culture des drogues ou ingrédients qu'on y emploie.*

“ If the manufactories of silk, wool, and thread,
“ are to be reckoned among those which most
“ contribute to the support of commerce ;
“ dyeing, which gives them that striking vari-
“ ety of colour, by which they resemble what
“ is most beautiful in nature, may be considered
“ as the soul of them, without which the body
“ could scarcely exist.

“ Wool and silk, the natural colour of
“ which rather indicates the rudeness of former
“ ages, than the genius and improvement of
“ the present, would be in no great request,
“ if the art of dyeing did not furnish attractions,
“ which recommend them even to the most
“ barbarous nations. All visible objects are
“ distinguished and recommended by colours ;
“ but, for the purposes of commerce, it is not
“ only necessary that they should be beautiful,
“ but that they should be good, and that their
“ duration should equal that of the materials
“ they adorn.” But though Colbert instituted
many useful regulations for the instruction of
the farmers and of the artists, he submitted to
that feudal spirit, which from views to the
revenue, multiplying the checks on commerce,
industry, and agriculture, impressed almost all
Europe with the idea, that such restraints were
necessary. Instead of confining himself to
such

such measures as might secure honesty of manufacture, and goodness of colour; instead of encouraging the seeds of commercial honour, the object of which is the public confidence, his restraints were excessive. In the dyeing of black cloth, he insisted upon it, that the operation should be begun with the dyers in grain, or those who give durable colours, and finished by those who employ only fading colours (*teinturiers en grand teint, & teinturiers en petit teint*); each was confined to a certain number of ingredients, and neither was suffered to have Brazil wood, &c.

The bad effects of this prohibition were moderated by the facility of eluding it, and by the rewards bestowed on those, whose experiments promoted the progress of the art, and whose discoveries were afterwards to be published, and to modify the existing regulations. French industry lost its preeminence by the criminal revocation of the edict of Nantz, which, carrying desolation into our manufactories, dispersed our workmen throughout Europe.

Since that time, the department of administration, to which the superintendence of arts and manufactures belongs, has constantly sought to repair our losses and encourage our exertions,

exertions, and particularly by diffusing knowledge, which, under wise laws, is the most efficacious means that can be employed.

Dufay, Hellot, and Macquer, have been successively charged with the care of improving the art of dyeing, and to their labours we are indebted for very valuable acquisitions. Dufay was the first who entertained just, though incomplete ideas, respecting the nature of colouring substances, and the powers by which they adhere ; he examined with great sagacity certain processes, and established the surest methods that could at that time be employed for determining the goodness of a colour, and this he did, in an easy and familiar manner. Hellot published a methodical description of the processes used in dyeing wool, which even now is the best treatise we have on the subject. Macquer has given an exact description of the processes employed in dyeing silk ; he has made us acquainted with the combinations of the colouring principle of Prussian blue ; he has endeavoured to make an application of it to the art of dyeing, and has given us a process for communicating the most brilliant colours to silk, by means of cochineal.

The solicitude of government on this subject, has, in the opinion of foreigners, been crowned

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ed with the success it merited. Mr. Anderson attributes the superiority, which certain articles of French manufacture maintain over those of the nations who possess the most beautiful wool, to the perfection of our dyes *, and Mr. Home expresses himself in the following manner.

“ The French are indebted to the academy of sciences, for their superiority in many of the arts, and especially that of dyeing ; but many distinguished philosophers have pursued with equal success, the example of the academy of sciences †.”

Macquer intended to have published a general treatise on the art of dyeing, the prospectus of which he gave us in the year 1781, but the indisposition which so long led us to expect his loss, prevented his engaging in it ; he died in 1784, before he had been able to carry into effect any part of his plan. I succeeded him in his place of trust, under the commercial department of administration, and was charged with the care of the arts connected with chemistry, and principally that of dyeing, since which time, almost all the investigations which I have inserted in the memoirs of the academy,

* History of commerce.

† Essay on bleaching.

in the *Journal de Physique*, and the *Annales de Chymie*, relate more or less to the theory and practice of the arts.

Chemistry has experienced a general revolution, which, by substituting fact in the place of hypothesis, with which we have heretofore been obliged to be contented, has afforded us an explanation of many obscure phenomena of nature and art.

Of all the arts, that of dyeing, perhaps with respect to its theory, requires the most extensive knowledge of natural philosophy; because it is that which presents the greatest number of phenomena to analyze, of uncertain changes to ascertain, and of relations to establish, with air, light, heat, and many other agents, of which our knowledge hitherto has been very imperfect.

Although the labours of the ingenious men above mentioned, and those of others, foreigners as well as Frenchmen, may have been very useful, whether in determining the essential circumstances of processes, and thus rendering them more simple and methodical; or in analyzing many substances employed in dyeing, and thus extending the resources of the art; or lastly, in discovering the causes of some particular phenomena; yet they have not been
able

able to form a theory which connects the art in all its branches, which does not even leave a great deal to wish for in every particular explanation, and above all, which brings into one point of view, the processes of industry, and the operations of nature.

I have endeavoured to take my situation between the philosopher, and artist ; to the first, I have shewn where it is that the phenomena of the art of dyeing, and the phenomena of nature meet, and what are the principles which their discoveries have established.

I have endeavoured to refer all the combinations produced in the formation of colours, to the laws of attraction, and all the changes which the colouring particles undergo, to the approximation of the elements of the new combination. In this distinction, I consider only two effects of attraction ; one, that by which the first combination is produced ; the other, that by which the elements of this combination obey their mutual attractions. The first is analogous to the formation of neutral salts ; the second, to combustion, putrefaction, and many other operations of nature. In the second part of my treatise, I have furnished them with a summary account of a very extensive art, which deserves their utmost

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attention, and which presents to their sagacity, a great number of interesting researches. They will pardon me if I frequently present objects with which they are familiar, if I sometimes repeat the same idea, and if out of regard to those who are not used to speculation, I dwell on illustrations, which to them would be useless.

To artists, I have presented the principles of Chemistry, so far as they are required in the explanation of the phenomena of dyeing; or rather, I have endeavoured to make them feel the necessity of an acquaintance with them; I have invited their attention to those objects most nearly connected with their art, and have furnished them with a sketch of the operations for making the substances they employ, with a view to induce them to qualify themselves for preparing such articles as they want, whenever that may be deemed advantageous; and also with a view, to give them an exact idea of the nature and properties of these substances. They ought however to excuse me, if while I have aimed at precision in describing processes, I have omitted any thing essential; if I have not always pointed out the best, and if some that are interesting have escaped me; the mystery which prevails in
most

most manufactures, is a great obstacle to those who labour for the improvement of the arts.

Both the philosopher and the artist will find me disposed to profit by their information, and to rectify the errors I may have committed, I wish them to consider me as a fellow-labourer, who desires to strengthen the ties by which they ought to be united ; and as a friend of reason, who enjoys, in retirement, the progress of knowledge, from whatever source it flows.

While they are granting indulgence to my weak attempts, I wish them to consider in me the civisme of the arts and sciences.

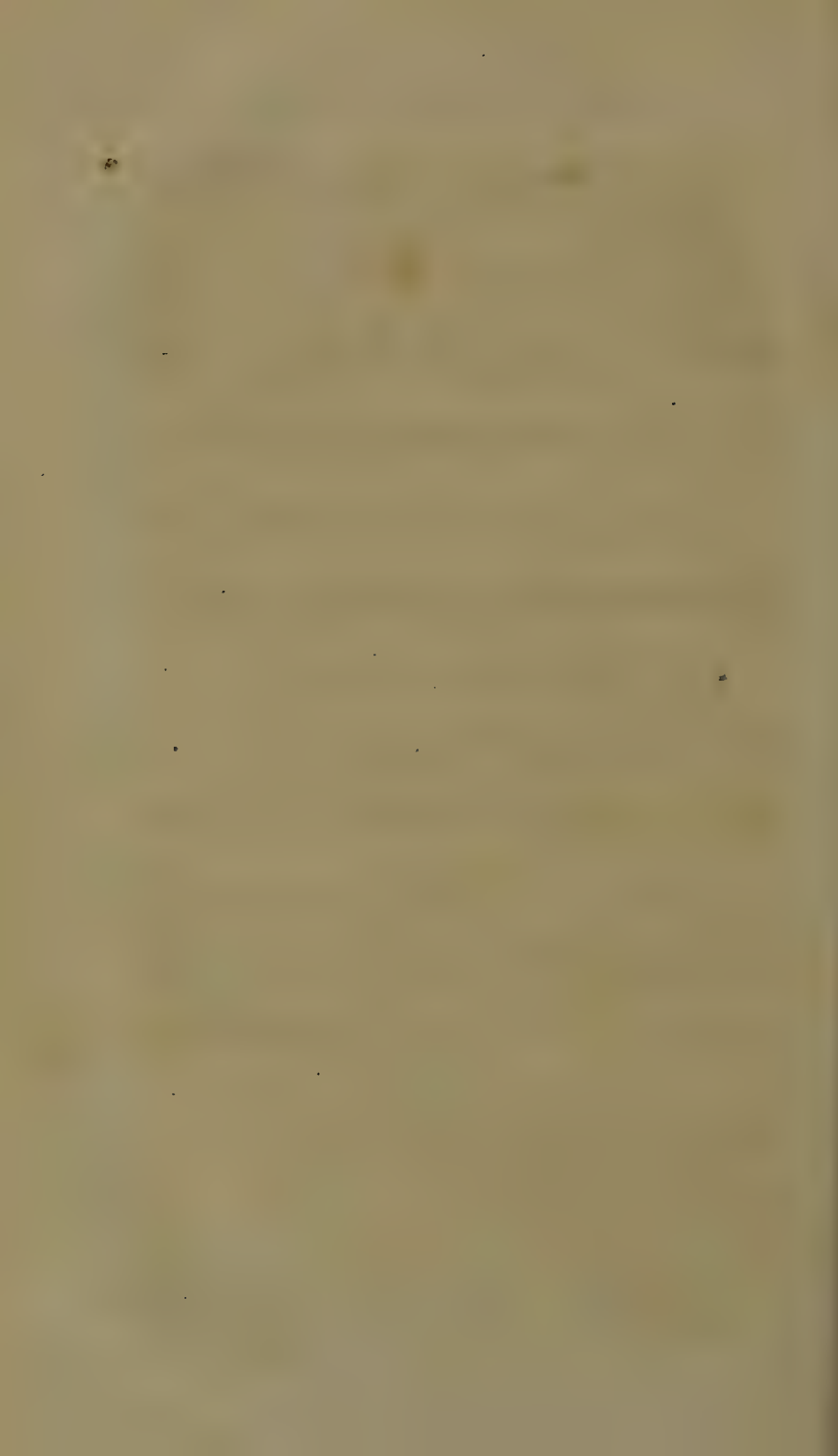
Experiments which relate to dyeing, are attended with peculiar difficulties. Since the beauty of a colour depends on a nicety of shade, which the slightest circumstance may effect, we are often disappointed, and what succeeds in a small essay, may fail in an operation on the large scale ; evaporation, which goes on proportionally faster in a small vessel, than in a large caldron, variations in the degrees of heat, the great difficulty of obtaining uniformity of colour, inequalities in the alternation of the action of the liquor, and of the air, the more difficult precipitation of the grosser parts, unite in rendering it very difficult to apply the most accurate experiments, to

operations on a large scale. Thus I have rather hinted, than proposed the changes, which may be attempted in the processes commonly employed ; I have described those which may be depended upon, or which are found in those works which most merit our confidence, confining myself, however, to circumstances which seem essential. The description of the processes is preceded by chemical experiments, which furnish us with a knowledge of the nature of the colouring materials employed in them, and more especially in the effects which may be produced by the ingredients used, or which might be used as means of uniting the colouring matter with the stuff (*intermédes*) : this is generally followed by observations on the most striking operations, on the differences required according to the intention, or according to the nature of the stuff, and on the application of the principles established in the first part of the work.

Hence it is evident that I have guarded against leading artists into error, by inducing them to change their processes prematurely ; it has been my design to qualify them for making experiments in their art, for explaining the phenomena that may occur, for selecting observations, and gradually introducing into
their

their manufactories, more simple, more varied, and more perfect methods.

In vain should I have conceived the hope of seeing artists enlightened by science, which teaches them to go back to causes, thence (as it were) to calculate effects ; if there were no chance of inducing a change in the usual mode of their education. But philosophy has paved the way for a reform, which is so consonant to the order established on the ruins of prejudice, and so powerfully recommended by illustrious example, more especially in a neighbouring nation, which has hitherto preceded us in the path of reason ; that I flatter myself I shall not be disappointed. The advancement of the arts ought to attract a consideration proportioned to its usefulness, and to the knowledge it demands ; more especially when the illusions of vanity, to the imputation of which the french character may have been liable, shall be for ever banished from the nation.



E L E M E N T S
OF THE
ART OF DYEING.

PART THE FIRST.
OF DYEING IN GENERAL.

S E C T I O N I.

Of the general Properties of Colouring
Substances.

C H A P T E R I.

Of Colouring Particles, and their Attractions.

AS the physical theory of colour is foreign to the subject of the present work, I shall make only a few observations on the action by which the particles of bodies, by absorbing certain rays of light, and transmitting or reflecting others, produce colours, before I enter

on the consideration of the properties of colouring substances.

Newton has demonstrated in his optics, that transparent bodies reflect the rays of one colour, and transmit those of another, according to the difference of their thickness or density. Mr. Delaval ^a has endeavoured to apply the Newtonian theory to the colours of all permanently coloured bodies, and has collected a great number of experiments, in order to prove, that the difference of colour in these bodies is exactly proportioned to the density of their constituent parts.

The application of the ingenious experiments on the colours reflected by thin and transparent laminæ, to the case of permanently coloured bodies, is founded upon analogies which did not escape the penetration of Newton; but the subject does not yet appear to admit of any direct proof, or inference, respecting particular colours; for first, the very same colours are successively produced by laminæ, the thickness of which is increased in a certain progressive order; so that we cannot determine by the kind of colour produced by a transparent lamina, which of all the different degrees

^a Experimental inquiry into the cause of the permanent colours of opaque bodies.

of thickness capable of producing the colour, that particular lamina possessed.

Secondly, the smallness and the density of the particles of bodies, are, according to Newton, two qualities, which combine to produce colour in transparent laminæ, and the thickness of the laminæ of water, of air, and of glass, must be different, in order to reflect the same colour; but we have no means whereby we can determine either the smallness or the density of the particles of bodies; their specific gravity will not answer this purpose, for small particles, with very numerous pores, may give the same specific gravity as larger pores and a smaller number of larger particles.

When Mr. Delaval asserts, that the series of colours which the metals communicate to glass, depends upon their specific gravity, he refutes himself by the facts which he relates; for he observes, that yellow glasses may be made either with iron, lead, or silver, which are very different in specific gravity.

Mercury, combined with a small quantity of oxygen^b is black, but by its union with a
larger

^b It may be proper to inform such readers as are not acquainted with the new nomenclature, adopted by many
of

larger quantity it assumes a red colour. Iron is capable of acquiring almost any colour, according to the quantity of oxygen with which it is combined, and the variations of specific gravity, resulting from these proportions of oxygen are very small, and much less considerable than the difference in the specific gravities of these metals.

The same author asserts, that alkalis change several vegetable blue colours to a green, because they increase the density of their particles ; and that acids change them to a red, because they lessen it by solution ; but alkalis

of the french chemists, that by this term is to be understood, that part of the pure or dephlogisticated air, which is united to metals during calcination ; it has therefore been also called the *basis of pure air* (see the annexed vocabulary).

What the other constituent part or parts of this fluid are, does not seem yet determined ; by some, it is supposed to be the matter of light ; by others, to be that of heat, called in the above-mentioned nomenclature, caloric (*calorique*) ; and by others, both are conceived to concur in its formation. Analogy, and even some observations, have led me to believe that light is not in every case necessary to the production of this fluid in its elastic state, but experiments are still wanting on the subject.

The etymology of the term is from Oξυς , acid, and $\gammaένεαι$, I generate, it being supposed the universal parent of acidity. T.

also

also dissolve most of the colouring substances, and render them much more miscible with water than they are naturally; they ought therefore to act like acids; besides, acids dissolve some blue colouring substances without changing their colour; thus the solution of indigo in the sulphuric (vitriolic) acid, retains its blue colour, even when diluted with a very large quantity of water, though according to Mr. Delaval's theory, the density of the blue particles must have suffered a material alteration. Finally, many vegetable substances become red or green, by means of a very weak acid, or a very small quantity of alkali, without its being possible to perceive the shades which ought to intervene.

The smallness and density of the particles are not the only circumstances which ought to be taken into the account; it appears even from Newton's experiments, that their chemical properties have a considerable influence on their colour, for doubtless a force which acts powerfully in refracting the rays, must likewise influence their reflection.

By comparing the refractive power of different bodies, Newton found that inflammable substances possess it in a much greater degree, than such as are not inflammable;
from

from his observations on this subject, he drew the wonderful conclusion, that the diamond contained a large quantity of inflammable matter, that water was an intermediate substance, between the inflammable and uninflammable bodies, and that it supplied vegetables with the inflammable principle; which truths have been seen and demonstrated only in the present day.

Many important observations still remain for those, who would follow the steps of that great man, and compare the refracting powers of the different gases, and other substances, the constituent principles of which are now known. Is it the hydrogen^c or the charcoal (charbon^d) which contributes most to the refracting power of inflammable substances? The experiments made on the diamond, would lead us to consider it as a pure, crystallized charcoal; but in the oil of turpentine, which has a considerable refracting power, the hydrogen is predominant.

^c The name given to the basis of inflammable air in the new french nomenclature, derived from *γῆρ*, water, and *γενεσθαι*, I generate. T.

^d It is supposed the author here means that substance, which in the same nomenclature is denominated *carbène* (*pure charcoal*) see vocabulary. T.

Many chemical experiments prove that oxygen has also a great attraction for light ; it combines with it, without separating the rays, and it recovers its elastic form in consequence of this combination, when it is not retained by a superior attraction (*affinité*) ; hence when oxygenated (*dephlogisticated*) muriatic acid, in which the oxygen is retained with but a small degree of force, is exposed to the light, it quits the acid and assumes its elastic form, as it becomes saturated with the matter of light ; a similar separation takes place when the nitric (*dephlogisticated nitrous*) acid is exposed to the rays of the sun, but with greater difficulty, because the oxygen is more intimately united with this acid. The oxygen may also be separated in the same manner, from some oxyds or metallic calces.

When a particular principle enters into the composition of any substance in a large proportion, it commonly shews its own properties by those which it imparts, however modified ; thus oxygen by its union with metals, enables them to act more powerfully on the rays of light, but with different degrees of force, on the different kinds of rays, until its attraction is so far weakened by heat, that all the rays may unite with it, and give it its elastic form.

Hence

Hence it is, that metallic oxyds change their colour, from small differences in the proportion of their oxygen. The oxyd of Manganese affords us a remarkable phenomenon in this respect; when saturated with oxygen, it appears black, if the particles are very close; but if they are diffused or dispersed, as in glass, which contains a certain quantity of this substance, it has a red tinge, which shews that its appearing black, arises only from the red particles being too near each other; if it be deprived of a great part of its oxygen, either by means of charcoal, or any other substance which is capable of separating that principle, the glass becomes quite transparent, and loses its colour; but it may be reproduced by nitre, or any other substance which restores to the Manganese the oxygen it had lost. In this way, its use in glass-making is explained; it destroys the carbonaceous or coaly matter which might injure the purity of the glass, and thus at the same time, becomes itself incapable of producing any colour, if it be employed in proper quantity.

In metallic oxyds, and many mineral substances, all the parts are equally coloured; but this is not the case in vegetable and animal substances; their colour is generally derived
from

from particles, which are mixed or combined with those of which these substances are formed, and vegetables commonly contain different colouring particles at different times of their growth, or in their different parts.

It is almost solely the colouring particles of vegetable and animal origin, that are used in dyeing, but they are frequently modified by different *intermedes*°. It is to these, that the name of colouring particles is given in this treatise (*parties colorantes*).

These colouring particles are not so simple in their composition, as those of mineral origin, and oxygen does not act upon the colours of both in the same way. How it acts upon, and changes them, will be explained in one of the succeeding chapters.

Some chemists have considered iron as the cause of all vegetable and animal colours; and Mr. Becker, in order to support this opinion, makes use of the argument drawn from the property which this metal so generally diffused over nature, has, of assuming a great variety of

° This term and that of mordant seem pretty nearly synonymous, both being applied to substances that modify colours, and make them strike, as it is commonly expressed by our dyers. Vid. Introduction, page xxxvi. T.

colours, when its oxyd (calx) is in a state of solution, or of vitrification^f.

Iron does in fact, appear to be contained in all vegetable and animal substances, but only in a very minute proportion. Oak, which is one of those vegetable substances that ought to afford the greatest proportion of residuum, leaves after combustion, only $\frac{1}{200}$ of its weight of ashes, and these do not contain $\frac{1}{200}$ of their weight of iron. Is it possible by so very small a quantity, to account for the rich and brilliant colours with which vegetables are adorned? Is there any remarkable connexion between the changeableness of some of these colours, by means of acids, alkalis, or air, and the regular succession of colours in iron, according to its degree of oxydation (calcination).

I know that the opinion which I am now opposing, may be supported by the suffrage of Bergman, who has attempted to prove that indigo owes its colour to the iron it contains^g; but I shall take the liberty of replying, that it is easy to shew, that this great chemist was

^f Specimen sistens experimenta circa mutationem colorum quorundam vegetabilium a corporibus salibus, cum corollariis; auctore I. F. Adolpho Becker, 1779.

^g Analyse chymique de l'Indigo. Mem. des Sav. étrang. tom. ix.

mistaken in this particular. By means of the prussiat of alkali ^h, he extracted from the ashes of one ounce of indigo, from thirty to thirty-two grains of Prussian blue, the iron of which he estimates to be from eighteen to twenty grains; but in other places, he shews that the iron contained in a substance, does not at the utmost exceed one fifth of the Prussian blue obtained from its solution; and in every other instance, he makes use of this calculation, which is very accurate. The quantity of iron therefore, he obtained from an ounce of indigo, ought to be reduced to six grains; in the experiments which follow, he shews that the greater part of this iron may be dissolved in the muriatic acid, without any change being produced in the colouring particles, so that the largest share of that metal did not enter into their composition. Hence it clearly follows, that the colouring particles in this substance must contain a quantity of iron, so small, as to have but very little influence on its colour. I am also inclined to think physiologists wrong, in concluding from the ex-

^h By this term is to be understood alkali, which has been boiled upon Prussian blue, commonly called phlogistigated alkali. T.

periments of Menghini, that iron is the immediate cause of the colour of the blood.

We are not only incapable by any of the means of chemical analysis we possess, of ascertaining the composition of the colouring particles, with a degree of precision, sufficient for discovering the principles to which they owe their properties; but it is also obvious that very different compositions may produce the same colour. The constituent matter of indigo is very different from that, to which most of our blue flowers owe their colour. We have a great number of yellow substances which afford colours very similar in their appearance, yet they are very different in their properties. There are simple colours, and there are others which result from a mixture of these, consequently of a compound nature. Newton has laid down a rule for the production of any given colour, by means of the other prismatic colours. Le Blon has shewn that all the colours required in painting, may be produced by different mixtures of red, blue, and yellowⁱ. Dufay has found, that the same might be accomplished in dyeing, and has

ⁱ L'Harmonie du coloris dans la peinture reduite en pratique.

thence inferred that there are only three primitive colours in nature, which produce all the rest, and this opinion has been adopted by many philosophers, though it is easy to prove it to be without foundation.

There is this difference between simple colours, and those produced by the union of different coloured rays, that the former viewed by means of a prism, retain their simplicity, while the latter are decomposed. Thus the green produced by the rays of that colour, suffers no decomposition by the prism, and has therefore the property of a simple and primitive colour; but that which is compounded, separates into blue and yellow. Although the green employed in dyeing, results from the mixture of blue and yellow, all greens are not to be considered as composed of two kinds of colouring particles; thus, the green in the oxyd of copper, cannot arise from particles of different kinds; and that of plants is certainly of a homogeneous nature, but this substance may produce green, either by reflecting the green rays, or by reflecting the blue and yellow; and there are many colours necessarily produced by the reflection of several different species of rays. If the green of plants arose from two substances, the one yellow, and the

other blue, it would appear extraordinary, that these could not be separated from each other, nor their proportions changed by means of menstrua; yet there are some substances which contain colouring particles of different kinds; such is madder, as will presently appear.

Green, which I take as an example of the colours in dyeing, that are really of a compound nature, demonstrates, that the colouring particles cover only a part of the surface of the stuff, though its colour may appear full and uniform; for after it has been dyed blue, the yellow particles still attach themselves, and produce green; and a proof that they are attached to the stuff principally, and not to the particles of indigo, is, that, though the process has been begun by applying the yellow first, provided it be not of too fixed a nature (*solide*) it may be destroyed by the air, and more especially by chemical agents, while the blue remains nearly unchanged.

Hence we see, that by mixing rays of different colours together, we may have the impression of a simple colour. In fact, an uniform colour may be produced by the mixture of different coloured wools; and in painting, simple shades result from the mixture of different ingredients which do not unite together.

The

The colouring particles form different combinations, and attach themselves either alone, or previously combined with other substances, to wool, silk, thread, and cotton. The art of dyeing consists in employing these attractions of the colouring particles, in order to extract, dissolve, apply, and fix them in the substances to be dyed.

It has been proposed to divide the colouring particles into extractive and resinous; but such a division can convey only partial and erroneous ideas of their properties; for there are some colouring particles, which not being soluble in water, would be considered as resinous, and yet they are not soluble in alcohol; such are the red colouring particles of bastard saffron, *carthamus* (*carthame*) which are only soluble by means of alkalis; and also, indigo, which is neither soluble in water, nor in alcohol, and dissolves in alkalis, only under particular circumstances, but very easily in the sulphuric acid.

The colouring particles which are soluble in water, cannot be considered as similar to the mucilaginous and extractive parts of vegetables, because the property of dissolving in water, like these substances, conveys no idea of the properties which it is essential to remark in

them, such as their affinities with the chemical agents employed in dyeing, with the air, with light, and with animal and vegetable substances.

The progress of true theory is also impeded by attempts to explain the properties of colouring substances, from the mucilaginous, resinous, earthy, saline, or oily particles, which are supposed to enter into their composition, in the way Mr. Poerner has done ; such attempts are similar to the vain explanations frequently offered respecting the action of medicines. (Vide Cartheuser's *Mater. Med.*)

We have just seen, that in explaining the cause of colour, and the nature of colouring particles, two great inconveniences have arisen ; first in the attempt to illustrate the action which the particles of colouring substances have on the rays of light, in consequence of their density and thickness, without having any means of ascertaining this, and without any regard to the attractions, which result from their chemical composition ; secondly, in comparing the colouring particles to mucilages and resins, from some very faint resemblances ; and in attempting to explain their colouring properties by conjectures, formed respecting their component parts, while these properties ought rather

rather to be ascertained by direct experiment, than explained by an imaginary composition. It was also departing from true theory, which is the result of observation alone, to ascribe to laws purely mechanical, the adhesion of the colouring particles to the substances dyed, the action of the mordants, the difference between the true or durable, and the false or fading dyes. Hellot, to whom we are indebted for the best treatise extant on dyeing, was completely wrong on this subject, and his theoretical ideas frequently influenced his observations, and the principles he laid down, as may be seen by consulting the work itself. Some judgment may be formed respecting his theory, from the following passage, “ I believe it may be
“ laid down as a general principle in the art
“ of which I am now treating, that all the
“ invisible mechanism of dyeing, consists in
“ dilating the pores of the body to be dyed,
“ in depositing in them, particles of foreign
“ matter, and retaining them there by a kind
“ of covering not liable to be affected by
“ water, rain, or the rays of the sun; in
“ choosing colouring particles of such a degree
“ of fineness, as to be rendered sufficiently
“ fixed in the pores of the stuff, opened by
“ the heat of the boiling water, and again

“ constricted by cold, and also coated by the
 “ kind of varnish (mastic) which the salts em-
 “ ployed in its preparation had left in these
 “ pores ; whence it follows, that the pores of
 “ the fibres of the wool, which has been
 “ wrought, or is to be wrought into cloth,
 “ should be cleansed, enlarged, coated over,
 “ and then constricted, so that the colouring
 “ particles may be retained in them, nearly in
 “ the same manner as the diamond is retained
 “ in the collet of a ring ^k. ”

It is surprising that Macquer, who was amongst the first who entertained just notions respecting chemical attractions, was led astray, by the ideas of Hellot. “ I should now explain (says he) the action of mordants in dyeing, and unfold the causes of durable and fading dyes ; but this subject has been treated of with so much sagacity by Mr. Hellot, that I shall refer the reader to him ^l. ”

Dufay

^k L'Art de la Teinture des Laines, p. 42.

^l This refers to a treatise on dyeing silk, published by Macquer, in 1763, entitled *Art de la Teinture en Soie. avant propos*, pag. 8, but that he was afterwards led to correct this opinion, is evident from the following passage, taken from the article dyeing, in his chemical dictionary, published in 1778, with his name affixed, vol. iv. pag. 26, “ That the above
 “ (alluding

Dufay however had before observed, that the colouring particles were naturally disposed to

“ (alluding to Hellot’s theory) is not the only reason however, is evident from a fact very well known in dyeing.

“ If after having alumed as completely as possible a pound of wool, and a pound of silk, each of them be dyed separately in a cochineal bath, they will both acquire a very fine and durable crimson ; but with equal quantities of cochineal in each bath (*bain*) the colour of the wool will be much more full and intense, than that of the silk, and the difference in this respect is so great, that the silk will not acquire so deep a crimson as the wool, unless more than double the quantity of cochineal be employed ; that is, two ounces and a half of cochineal are requisite for giving the pound of silk as full a crimson, as that which is produced in the pound of wool by one ounce of the same substance ; and we cannot say with Mr. le Pileur d’Apligny, that this proceeds from the pores of the silk being much smaller than those of the wool, and being able to receive only the finest colouring particles of the cochineal, while the wool receives them all, because its pores are either larger or more numerous ; if this were the case, the bath in which the silk had taken up all that it was capable of receiving, should still retain a considerable quantity of the colouring matter ; but this by no means happens ; on the contrary, it is certain, that silk dyed with the proportion of two ounces and a half of cochineal to the pound, leaves its bath as clear and as much exhausted of its colour, as one prepared for the same quantity of wool, with only one ounce of cochineal.” And he afterwards proceeds to attribute it, to a chemical union of the colouring particles to the matter of

to adhere more or less firmly, to the filaments which receive them^m; he remarks very justly, that without this disposition, stuffs would never assume any colour, but that of the bath, and would always divide the colouring particles equally with it; whereas the liquor of the bath sometimes becomes as limpid as water, giving off all the colouring particles to the stuff; “ which seems to indicate (says he) that the “ ingredients have less attraction for the water,

of the stuff dyed, either immediately or by the intervention of mordants; and concludes thus: “ From these effects “ we see evidently, why the extractive colouring particles “ cannot strike a colour, without the assistance of a mordant “ previously applied to the stuff to be dyed; it is plain, “ that the composition of the mordant, the precipitation of “ earthy, or metallic basis, and finally the union of the “ colouring particles with these earthy or metallic substances, “ take place in the stuff impregnated with the mordant, “ when it is immersed in a decoction, which holds this “ colouring matter in solution; and hence it follows, that “ in all cases of colours struck in this manner, which are “ very numerous, it is not the stuff immediately which “ takes the colour, but the earthy or metallic part of the “ mordants; so that when stuffs are well dyed by these “ processes, it is owing to these coloured precipitates being “ capable of adhering to them, more or less forcibly.” *D'un maniere plus ou moins solide.*

^m Observations physiques sur le melange de quelques couleurs dans la teinture. Mem. de l'Academ. 1737.

“ than

“than for the particles of the wool;” he adds, that many other phenomena might be accounted for in the same way; but that such an explanation still leaves a great deal to be wished for, and that he would relinquish it readily, if a more probable one should be proposed.

Bergman seems to have been the first who referred phenomena of dyeing, entirely to chemical principlesⁿ; having dyed some wool and some silk in a solution of indigo, in very dilute sulphuric acid, he explains the effects he observed in the operation, by attributing them to the precipitation occasioned by the blue particles having a stronger attraction for the particles of the wool and silk, than for those of the acidulated water; he remarks, that this attraction of the wool is so strong, as to deprive the liquor entirely of the colouring particles; but that the weaker attraction of the silk, can only diminish the proportion of these particles in the bath; and he shews, that both the durability of the colour, and the degree of intensity it is capable of acquiring, depend on these different attractions. This is, in fact,

ⁿ Analyse de l'indigo. Mem. des Sav. etran. tom. ix. and in the notes on Scheffer's treatise,

the true light in which the phenomena of dyeing should be viewed; they are real chemical phenomena which ought to be analyzed in the same way as all those dependant on the actions which bodies exert, in consequence of their peculiar nature.

The colouring particles possess chemical properties, that distinguish them from all other substances; they have attractions peculiar to themselves, by means of which they unite with acids, alkalis, metallic oxyds, and some earths principally alumine. They frequently precipitate oxyds and alumine, from the acids which held them in solution; at other times they unite with the salts and form supracompounds^o, which combine with the wool, silk, cotton, or linen. And with these, their union is rendered much more close by means of alumine or a metallic oxyd, than it would be without their intervention.

The difference in the attractions of the colouring particles for wool, silk, and cotton, is

^o In the original *surcompositions*, by which is to be understood compounds of more than two ingredients. I have rendered it by the above word, as the idea seems borrowed from Beccher and Stahls mixts, compounds, decompounds, and supradecompounds, though the application of the term is more vague. T.

sometimes

sometimes so great, that they will not unite with one of these substances, while they combine very readily with another; thus cotton receives no colour in a bath which dyes wool scarlet. Dufay got a piece of stuff made, the warp of which was wool and the woof cotton, which went through the process of fulling, that he might be certain that the wool and the cotton received exactly the same preparation; but the wool took the scarlet dye, and the cotton remained white. It is this difference of attraction which renders it necessary to vary the preparation, and the process, according to the nature of the substance which we wish to dye of a particular colour.

These considerations ought to determine the road to be pursued, for the purpose of improving the art of dyeing.

It is certainly proper to endeavour to ascertain, what are the constituent principles of the colouring particles; for though such an investigation cannot of itself lead to an extensive application at present, yet it would appear, that we have attained a knowledge of the nature of the modifications produced in these particles by different agents.

The essential circumstances are, to determine the affinities of a colouring substance, first, with the substances which may be employed as men-

strua; secondly, with those which may by their combinations modify the colour, increase its brilliancy, and help to strengthen its union with the stuff to be dyed; thirdly, with the different agents which may change the colour, and chiefly with air and light.

It must be remembered, that the qualities of the uncombined colouring particles are modified when they unite with a substance; and if this compound unites with a stuff, it undergoes new modifications; thus the properties of the colouring particles of cochineal are modified, by being combined with the oxyd of tin, and those of the substance resulting from this combination, are again modified by their union with the wool or silk; so that the knowledge we may acquire by the examination of colouring substances in their separate states, can only inform us respecting the preparations that may be made of them; that which we acquire respecting their combinations with substances which serve to fix them, or to increase their beauty, may inform us what processes in dyeing ought to be preferred or tried; but it is only by direct experiment made with the different substances employed in dyeing, that we can confirm our conjectures and establish the processes.

In the course of these observations, we shall frequently

frequently be able to point out the rationale of the circumstances in operations, that depend only upon practice unenlightened by science, but yet enriched by the trials of many ages; we shall be able to retrench what is superfluous, to render simple what is complicated, and to employ analogy for the purpose of transferring to one process, that which is advantageous in another; but still a considerable number of facts will occur, which we cannot explain, and which are not reducible to any theory: we must then content ourselves with detailing the process of art, without attempting to give new explanations, and wait for further light from experience.

From the preceding observations, it follows, that the changes produced by acids and alkalis on many vegetable colours, such as the chemists often employ, in order to discover the nature of different substances, are owing to the combinations which take place between these colouring particles and the acids and alkalis. The compounds resulting from these combinations, may be compared to neutral salts, which possess qualities different from those of their component parts, but in which one of these parts may be in excess, and its qualities consequently be predominant. This state of combination is observable between the colouring particles of
cochineal

cochineal and acidulous tartrite of pot-ash, or cream of tartar; by evaporating slowly, a solution of this salt in a decoction of cochineal, crystals are formed, which retain a fine ruby colour, much more bright and intense than that of the liquor in which they were formed.

There are some acids, particularly the nitric, which after having combined with the colouring particles, change the colour which they at first produced, make it yellow, and destroy it. They then act by means of one of their principles, the oxygen, in a manner which will be explained, in treating of the action of air and oxygenated muriatic acid, on the colouring particles. Blue colours are not the only ones which become red by the addition of acids, and green by that of alkalis; most red colours, as that of the rose, c. g. are heightened by acids, and made green by alkalis; and some green colours, such as that of the green decoction of burdock, according to Mr. Nose^p, and the green juice of buckthorn. (*Rhamnus Catharticus*) according to Mr. Becker, are reddened by acids. This property, which is common to most of the ordinary colours of vegetables, seems to prove, that there is a great analogy between their colouring particles; and

^p Versuche einiger beytrage zur chymie.

it is not without foundation, that Linnæus supposed^a, that the red in vegetables was owing to an acid, and indicated its presence^r; but there are also many vegetables which contain acid in a disengaged state, without having a red colour.

The colouring particles then have attractions for acids, alkalis, earths, and metallic oxyds, which constitute a part of their chemical properties; and in consequence of which, their colours are more or less changed.

These particles then form, with the stuff^s on which they are fixed, a compound, which retains only some of their original properties; they are also modified by their union with alumine, metallic oxyds, and some other substances, as are also those new compounds, when they are further combined with the stuff; all these modifications

^a Amœnitatum acad. tom. iv.

^r There are some flowers, the colour of which seems to be naturally modified by a very weak acid, without being properly red; such are the flowers of the violet, the red juice of which becomes blue, when suffered to remain for some time in a tin vessel; probably because the acid which it contained, combines with the oxydated (calcined) part of the surface of the tin; such also are the flowers of mallow, which become blue by simple exsiccation; the original colours are restored by a very minute portion of acid. *Observ. physico-chym. sur les couleurs, par M. Opoix, Journ. de Phys. tom. xiii.*

^s In the course of this work, by stuff, is meant any substance that is dyed, whatever may be its nature or form.

are analogous to what is observed in other chemical combinations: we shall now proceed to the consideration of them in detail.

C H A P. II.

Of Mordants.

THE title Mordant is applied to those substances which serve as intermedes between the colouring particles and the stuff to be dyed, either for the purpose of facilitating or of modifying their combination.

Mordants merit the greatest attention; as, by their means colours are varied, brightened, made to strike, and rendered more durable.

The analysis of the action of mordants in particular, constitutes dyeing a chemical art, and a more complete knowledge of their effects, would contribute in an eminent degree to the perfection of that art.

In the third section, I enumerate the essential qualities of the chemical agents most employed as mordants. I ascertain, when speaking of each colouring substance, the effects they produce on it.

In

In this chapter, I shall examine the nature of the action of the principal mordants, and shall endeavour to determine, how their attractions serve to unite the colouring particles with the stuff, and how they affect the qualities of the colours.

A mordant is not always a simple agent, and new combinations are sometimes formed by the ingredients that compose it; so that the substances employed, are not the immediate agents, but the compounds which they have formed.

Sometimes the mordant is mixed with the colouring particles, and sometimes the stuff is impregnated with it; on other occasions, both these modes are united; and finally, we may dye successively with liquors containing different substances, the last of which only can act on the particles with which the stuff is impregnated.

As the art of printing linen affords many processes, in which it is easy to observe the effects of mordants: I shall quote a few examples from it, which will render the theory hereafter proposed, more intelligible.

The mordant employed for linens intended to receive different shades of red, is prepared by dissolving in eight pounds of hot water, three pounds of alum, and one pound of acetite of lead, or sugar of lead, to which two ounces of

pot-ash, and afterwards two ounces of powdered chalk, are added ^a.

The alum is decomposed by the acetite of lead, because the oxyd of lead combines with the sulphuric acid, and forms an insoluble salt which is precipitated; the base of the alum or alumine (*the argillaceous earth*) at the same time combines with the acetous acid, and produces an acetite of alumine; the chalk and pot-ash serve to saturate the excess of acid.

One advantage resulting from the formation of the acetite of alumine is, that the alumine is retained in it by a much weaker attraction than in the alum, so that it more easily quits its menstruum, to combine with the stuff and the colouring particles.

A second advantage is, that the acid liquor from which the alumine is separated, has much less action on the colour when it consists of the acetous, than when it consists of a stronger acid, such as the sulphuric.

Finally, the acetite of alumine not having the property of crystallizing, the mordant, which is thickened with starch or gum to prepare it for being applied to the block on which the design

^a We shall enter into the detail of this operation, when treating of madder, in the second volume.

is engraved, does not curdle as it would if it contained alum, which would crystallize.

Let us attend to the operation performed upon a piece of linen cloth: when it has been impregnated by the mordant, in the manner determined by the design, it is put into a bath of madder; the whole of the cloth becomes coloured, but the tinge is deeper in those parts which have received the mordant; there the colouring particles have combined with the alumine and the cotton, so that a triple compound has been formed, and the acetous acid separated from its basis is carried off in the bath.

The colouring particles combined with the alumine and the stuff, are much more difficultly affected by external agents, than when they are in a separate state, or combined only with the stuff, without any intermediate bond of union; and it is on this property that the operations, to which the cloth is afterwards subjected, are founded: after it has been maddered, it is boiled with bran, and spread upon the grafs; and these operations are alternately repeated, until the ground becomes white. The colouring particles which have not united with the alumine, are altered in their composition, dissolved, and separated, whilst those that have combined with it, remain, and are preserved,

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without

without alteration ; and thus, the design alone remains coloured.

This destruction of the colouring particles by exposure on the grass, and boiling with bran, seems to be accomplished in the same manner as that of the colouring particles of flax, and to admit of the same explanation. The only difference consists in substituting bran for alkalis, because they would dissolve a part of the colouring matter which is fixed by the alumine, and would change its colour ; instead of which, the bran having a much weaker action on this substance, affects only the colouring particles, which, by the action of the air, have been disposed to a more easy solution.

If, instead of the mordant I have mentioned, a solution of iron be employed, the same phenomena take place ; the colouring particles decompose the solution of iron, and form a triple compound with the stuff ; but, instead of red, we get from the madder brown colours of different shades, down even to black ; and, by uniting these two mordants, alum and iron, we have mixed colours, inclining to red on the one hand, and to black on the other, such as mordoré and puce colour.

Finally, we get other colours, by substituting dyers weed for madder, and by means of these

two colouring substances, indigo, and the two mordants above mentioned, we obtain most of the different shades observed in printed stuffs.

The substances which compose a mordant, are sometimes incapable of decomposing each other solely by their own attractions; but the attraction of the stuff for one of their constituent parts, brings about a decomposition and new combinations, and sometimes this effect is not produced or completed without the aid of the attraction of the colouring particles. This appears to be the case in the mixture of alum and tartar, one of the most common mordants employed in the dyeing of wool.

I dissolved equal weights of alum and of tartar, the latter salt by this mixture acquired a greater degree of solubility than it naturally possesses; but, by evaporation and a second crystallization, the alum and the tartar were separated, so that they had not decomposed each other. I boiled for an hour, half an ounce of alum with an ounce of wool; a precipitate was formed, which I washed carefully; it consisted chiefly of small filaments of wool incrustated with earth: to this I added sulphuric acid, and evaporated to dryness, dissolved it, and obtained crystals of alum; some carbonic particles separated from it: I evaporated the liquor in which the wool had

been boiled, but obtained from it only a few grains of alum; the remainder would not crystallize: I redissolved it, and precipitated the alumine by an alkali; the precipitate was of a slate colour, it grew black upon a red-hot coal, and emitted alkaline vapours.

By this experiment we see, that the wool had decomposed the alum; that a part of the alumine had combined with its most detached filaments, which were least retained by the force of aggregation; that a part of its animal substance had been dissolved, and precipitated by the alkali, from the triple combination which it had formed.

I made the same experiment with half an ounce of alum and two drams of tartar; no precipitation took place; I obtained by evaporation a small portion of the tartar, and some very irregular crystals of alum; the rest would not crystallize: this I diluted with water, precipitated by pot-ash, and obtained, by evaporation, a salt which burned like tartar.

The wool which had been boiled with the alum felt harsh, but the other had preserved its softness. The first had acquired from the madder a more dull though lighter tint, but the colour of the latter was more full and bright.

I cannot enter into a minute explanation of what took place in these experiments; but we see,

see, first, that the wool had begun a decomposition of the alum, that it had united with a part of the alumine, and that even the part of the alum which retained its alumine, had dissolved some of the animal matter: secondly, that the tartar and alum, which cannot decompose each other solely by their own attractions, become capable of acting on each other, when their attractions are assisted by that of the wool: thirdly, that the tartar appears principally useful for moderating the too powerful action of the alum upon the wool, whereby it is injured; for tartar is not used in the aluming of silk and thread, which have less action on the alum than wool has.

As the decomposition of alum by the tartar and wool, takes place in consequence of attractions which nearly balance each other, and the process must therefore go on slowly, we see why it is useful to keep the stuff impregnated with alum and tartar, for some days in a moist place, as is recommended.

The final effect of aluming, in whatever manner performed, and whatever chemical changes may have taken place in it, consists in the combination of alumine with the stuff: this union has probably been imperfect, and the acids only partially separated, but becomes complete when
the

the cloth has been boiled with the madder, as we have seen in the case of printed stuffs.

An acid or an alkali may, however, form a supracompound with the stuff, the colouring matter, and the alumine; for there are some colours which are changed by an acid and restored by alkalis, or by calcareous earths, which take the acid from them, or vice versa: but this supracomposition does not take place with respect to those colours which are esteemed durable, being unchangeable by alkalis or acids, which are not strong enough to destroy their composition.

The attraction of alumine for animal substances, is not merely indicated by uncertain appearances, nor supposed, for the purpose of being employed in explanations, but is proved by direct experiment. I united them together, by mixing an animal substance with a solution of alum, a double exchange took place, the alkali entered into combination with the acid of the alum, and the alumine, combined with the animal substance, was precipitated^b.

I proved the attraction of alumine for animal substances by another experiment; having mixed a solution of glue with a solution of alum, I precipitated the alumine by an alkali, and the

^b Mem. de l'acad. 1784.

glue with which it had combined, fell down along with it. This compound has the appearance of a semitransparent jelly, and grows dry with difficulty^c. Thus we have also seen in the preceding experiments, that the alkali precipitated the alumine combined with the animal substance, from the uncrySTALLIZABLE residue of the alum which had been boiled with the wool.

The attraction of alumine for most colouring substances, may also be shewn by direct experiment. If a solution of a colouring substance be mixed with a solution of alum, a precipitation sometimes takes place; but if to the liquor we add an alkali, which decomposes the alum, and separates the alumine, the colouring particles are then precipitated, combined with the alumine, and the liquor remains clear: this compound has got the name of Lake. In this experiment, too much alkali must not be added, because alkalis are capable of dissolving most lakes.

No direct experiment has yet shewn, that alumine attracts any vegetable substance except the colouring particles; its attraction for them seems much weaker than that which it has for animal substances; hence the acetite of alumine, as has been already observed, is a better mor-

^c Ann. de Chymie, tom. iv. p. 155.

dant for cotton and linen than alum is, and upon this depend the different means employed to increase the fixity of the colouring particles of madder in the dyeing of these substances.

Metallic oxyds have so great an attraction for many colouring substances, that they quit the acids in which they were dissolved, and are precipitated in combination with them.

On the other hand, all metallic oxyds have the property of uniting with animal substances; and I have formed these different compounds, by mixing an alkali saturated with an animal substance, with metallic solutions ^d.

It is not surprising, therefore, that metallic oxyds should serve as a bond of union between the colouring particles and animal substances; but, besides the attraction of the oxyds for the colouring particles and for animal substances, their solutions in acids possess qualities, which render them more or less fit to act as mordants: thus, those oxyds which easily part with their acids, such as that of tin, are capable of combining with animal substances, without the aid of colouring particles; it is sufficient to impregnate the wool or the silk with a solution of tin, although they be afterwards carefully washed,

^d Mem. de l'acad. 1784.

which is not the case with other metallic solutions.

Some metallic substances afford in combination, only a white and colourless basis; and some, by the admixture of their own colour, modify that which is proper to the colouring particles; but in many metallic oxyds, the colour varies according to the proportion of oxygen they contain, and the proportion of this is easily liable to change. Upon these circumstances, which will be examined in the conclusion of this section, their properties in dyeing principally depend.

The attraction of metallic oxyds for substances of vegetable origin, seems much weaker than that which they have for animal substances, and we are even ignorant whether they be capable of contracting a real union with them or not: metallic solutions are therefore ill fitted to serve as mordants for colours in cotton or linen, except iron, the oxyd of which unites firmly with vegetable substances, as is shewn by iron moulds, which are owing to a real combination of this oxyd.

When the colouring particles have precipitated a metallic oxyd from its menstruum, the supernatant liquor contains the disengaged acid, which is commonly capable of dissolving a por-
tion

tion of the compound of colouring substance and oxyd, so that the liquor remains coloured; but sometimes the whole of the colouring particles are precipitated, when the proportions have been accurately adjusted: this precipitation is facilitated, and rendered more complete, by the presence of the stuff, which assists, by the tendency it has to unite with the compound of oxyd and colouring particles.

Uncombined metallic oxyds have also a very evident action on many colouring substances when boiled with them, and modify their colour; the oxyd of tin in particular, increases the brightness and fixity of several.

The compounds of oxyds and colouring substances may be compared to many other chemical compounds, which are insoluble, when the principles of which they are formed are properly proportioned; but which are capable of being supersaturated by an excess of one of the principles, and thence of becoming soluble. Thus a metallic oxyd united with a colouring substance in excess, will produce a liquor, the colour of which will be modified by the oxyd, whereas, when the colouring matter is not in excess, the compound will be insoluble, or nearly so;

* Observations on the combination of metallic oxyds with the astringent and colouring matter of vegetables. *Ann. de Chym.* tom. i.

these

these effects are very evident in the combination of iron with the astringent principle.

Neutral salts, such as nitre, and particularly muriat of soda (common salt) act as mordants, and modify colours; but it is difficult to ascertain the manner in which they act. I have found, that the muriat of soda was contained in substance, in the precipitates produced by some species of colouring particles, and that these precipitates retained a considerable degree of solubility; it would seem, that a small part of the salt becomes fixed with the colouring particles and the stuff.

Salts with calcareous bases also modify colours; but as these modifications are nearly similar to those which would be produced by the addition of a small quantity of lime, it is probable that they are decomposed, and that a little of the lime enters into combination with the colouring particles and the stuff.

If we attend to what has been now said, we shall easily discern, what combinations are formed by the agency of the different reactives employed in the analysis of colouring substances; but we must not forget, that the mordants and the colouring particles have a mutual action on each other, which may change their properties.

We already perceive, that by varying the
mordants,

mordants, we may multiply prodigiously the shades obtained from a colouring substance; to vary their mode of application even, may be sufficient: thus we shall have different effects, by impregnating the stuff with the mordant, or by mixing the mordant with the bath; by applying heat, or using exsiccation; for we operate upon three elective attractions; that of the colouring particles, that of the stuffs, and that of the principles of the mordant; and many circumstances may cause variations in the result of these attractions; circumstances which merit further explanation. Exsiccation favours the union of the substances which have an attraction for the stuff, and the decompositions which may result from that union; because the water which held these substances in solution, by its attraction, opposed the action of the stuff; but the exsiccation should be slow, in order that the substances may not be separated before their mutual attractions have produced their effect. Hence we learn, how the repeated exsiccations employed in some processes produce their effect.

The greater or less disposition of the stuff to unite with the colouring particles, sometimes occasions considerable differences in the mode of employing the mordant; thus, when this disposition is strong, the mordant may be mixed
with

with the colouring substance; the compound then formed, unites with the stuff immediately: but if it be weak, the compound formed by the colouring particles, and the substance employed as intermede, may separate, and be precipitated, before it can be attached to the stuff. To prevent this inconvenience, we must begin, by attaching to the stuff, the substance which is to serve as the medium of union between it and the colouring particles. From these observations, I shall deduce the explanation of the differences that occur in the processes employed in dyeing wool or silk black, or with cochineal.

To judge of the effects of mordants, and of the most advantageous manner of employing them, we must then, independently of the considerations afterwards to be mentioned, pay attention, first, to the combinations which may be produced, either by the action of the substances which compose them, or by that of the colouring particles and the stuff; secondly, to the circumstances which may concur, in bringing about these combinations more or less quickly, or in rendering them more or less complete; thirdly, to the action that the liquor in which the stuff is immersed may have, either on its colour or texture; and in order to foresee what that action may be, it is necessary to know the

proportions of the principles which enter into the composition of the mordant, and what will be left in an uncombined state in the liquor.

Mordants are not obtained from the class of salts alone; vegetable and animal substances serve as mordants for each other under certain circumstances; thus, in the process for Adrianople red, of which there is a description in the second volume, the cotton ought to be impregnated, or rather combined with an animal substance; and thus, the astringent principle is often employed as a medium of union between colouring particles and stuffs.

No one has hitherto varied mordants, and their mode of application, more than Mr. Poerner, and in that respect, his works may be of great utility, particularly that which has been just translated ^f.

^f Instruction sur l'art de la teinture, & particulièrement sur la teinture des laines; chez Cuchet, rue & hôtel serpente.

C H A P. III.

Of the Action of different Substances, particularly of Air and Light on Colours.

WE have hitherto considered the colouring particles, only as substances capable of forming different combinations, by which their properties are modified; but they may be altered in their composition, either by other external agents, or by the substances with which they unite.

It is proper to begin with an examination of the changes produced by external agents, because they are more easily ascertained.

The stability of a colour consists in its power of resisting the action of vegetable acids, alkalis, soap, and more especially that of the air and light; but this power varies exceedingly, according to the nature of the colour and the species of the stuff; for the same durability is not required in the colours of silk as in those of wool.

There is no obscurity in the action of water, acids, alkalis, or soap; it is a solution brought about by these agents; and it appears that a small quantity of acid or of alkali, sometimes unites with the compound which gives the colour;

because the colour is not destroyed, but only changed, and may be restored, by taking away this acid, as for example, by means of chalk or ammoniac (volatile alkali).

This is not the case with respect to the action of air and of light. Hitherto, the nature of their action was not understood; but at present, considerable advances being made in this theory, it is found that nothing but experiment is wanting, to lead us to an accurate knowledge of the subject.

Scheele had observed, that the oxygenated marine acid rendered vegetable colours yellow, and he attributed that effect, to the property it had of taking up the phlogiston which entered into their composition.

I have shewn ^a that the properties of the oxygenated marine acid, were owing to the combination of its oxygen, with the substances exposed to its action; that it commonly rendered the colouring particles yellow; but that by a continuance of its action, it destroyed their colour; without determining in what this action consisted.

Mr. Fourcroy has since made several observations on the action of oxygen on the colouring particles, which throw a great deal

^a Mem. de l'acad. 1785.

of light on the nature of the changes they undergo, chiefly when watery solutions of them are left exposed to the air, or have been subjected to a boiling heat; he observed, that in consequence of the action of the air, vegetable decoctions formed pellicles, which lost their solubility and underwent successive changes of colour; he marked the gradations of colour thus produced, and concluded from his observations, that oxygen entered into the composition of the colouring particles; that when it combined with them, their shade was changed; and that the more they received, the more fixed did their colour become; and that the best method of obtaining permanent unchangeable colours for painting, was to choose such as had been exposed to the action of the oxygenated marine acid ^b. I have been employed more particularly, in a memoir of which I shall now give an abstract, in attempting to ascertain, in what the action of the air on colours of different kinds consists, by analyzing that of the oxygenated marine acid ^c.

In considering the effects of air on colours, it is necessary to make a distinction between

^b Ann. de Chym. vol. v.

^c Ibid. vol. vi. Mem. sur l'action que l'acide muriatique oxygéné exerce sur les parties colorantes.

those produced by metallic oxyds, and those produced by the colouring particles. I had proved that the modifications of the former, were entirely owing to different proportions of oxygen, as already mentioned in the first chapter of this section; but observation led me to form a different opinion respecting the modifications of the latter.

I have observed, that the oxygenated marine acid exhibited different phenomena with the colouring particles, that sometimes, it discharged their colour and rendered them white, that most frequently it changed them to a yellow, fawn colour (*fauve*^d) brown, or black, according to the intensity of its action; and that, when their colour appeared only discharged or rendered white, heat, or a length of time, was capable of rendering them yellow. I compared the effect produced by the oxygenated marine acid, when the particles are rendered yellow, fawn coloured, or brown, with the effect of a slight degree of combustion, and shewed that they were the same, that they

^d Though *fauve* is here translated in the usual manner (fawn colour) it does not appear to mean what we commonly understand by that appellation; for in other parts of the work, it is called *rust colour*, and applied to that kind of brown which is produced by walnut peels, &c.

were owing to the destruction of the hydrogen, which combining with the oxygen, more easily, and at a lower temperature than charcoal does, leaves it predominant, so that the natural colour of charcoal, is more or less blended with that which before existed.

This effect becomes very evident, when sugar, indigo, or the infusion of the gall nut, or of fumach, are exposed to the action of oxygenated muriatic gas (dephlogisticated marine acid air); the sugar and the indigo assume a deep colour, and afford indisputable marks of a slight combustion; the infusion of the gall nut, and that of fumach, let fall a black precipitate, which is nearly pure charcoal.

These phenomena are analogous, to those which are observed in the distillation of organized substances; in proportion as the hydrogen is extricated in the form of oil, or of gas,

* This term is adopted by most of the french chemists, to denote those permanently elastic fluids, commonly called airs by english chemists. It occurs first, I believe, in Van Helmont's treatise de Aquis Spadanis, wherein he calls the carbonic acid gas of the authors of the new french chemical nomenclature, the fixed air of Drs. Black, Priestley, &c. by the name of gas, or gas sylvestre, supposed to be derived from the German *Geist*, spirit. T.

the substance grows yellow, and at length, there remains only a black coal. If the hydrogen be expelled from an oil by heat, it grows brown in the same manner.

Other experiments which I had made on alcohol and on ether, had shewn me, that the oxygen united to the marine acid, had the property of combining with the hydrogen, which abounds in these substances, and of thereby forming water.

When therefore the oxygenated marine acid renders a colour yellow, fawn coloured, or brown, this effect proceeds from the colouring matter having undergone a slight combustion, by which, more or less of its hydrogen has been converted into water; and the charcoal thus rendered predominant, has communicated its own colour.

I have shewn that the art of bleaching linen by means of the oxygen of the atmosphere, of the dew, and of the oxygenated marine acid, depended on this change of the colouring matter. The colouring particles of the flax are rendered soluble in the alkaline lixivium, the action of which ought to alternate with that of the oxygen. These colouring particles may be afterwards precipitated from the alkali, and by evaporation and drying become black,
and

and prove the truth of this theory, both by the colour they have acquired, and by the quantity of charcoal which they yield by analysis.

The alkaline solution of the colouring matter of linen, which is of a dark brown colour, loses its colour almost entirely, by the addition of a certain quantity of oxygenated marine acid; and the same effect is observable in many other substances, which have assumed a colour proceeding from an incipient combustion.

A piece of linen which appears white may yet grow yellow in the course of time (more especially if exposed to a certain degree of heat) if the oxygenated parts have not been removed by a sufficiently strong lixivium; in like manner, the green parts of vegetables are rendered white by the oxygenated marine acid, but become yellow by being boiled.

These facts shew that oxygen is capable of whitening, or rendering paler, the colouring matters with which it unites, perhaps by having produced the effects of a slight combustion upon them; or possibly, these effects take place only afterwards in a slow manner, but more readily, when the whole is exposed to a certain degree of heat. It is very probable
that

that in all cases a part of the oxygen unites with the colouring matter, without being combined with the hydrogen in particular, and that it is in this way, that oxygen renders the colouring matter of flax more soluble in alkalis.

Oxygen has certainly an influence in many other cases, on the changes which take place in the colouring particles of vegetables ; these particles are formed chiefly in the leaves, flowers, and inner bark of trees ; by degrees they undergo a slight combustion, either from the action of the atmospheric air which surrounds them, or from that of the air which is carried by a particular set of vessels, into the internal parts of vegetables ; hence, most trees contain fawn coloured particles, inclining more or less to yellow, red, or brown, which, in consequence of this combustion, grow thick, and are at last thrown out of the vascular fibres of the bark, the greatest part of which I have found composed of them.

These observations teach us how the air acts upon colouring matters, of an animal, or vegetable nature ; it first combines with them, renders them weaker and paler, and by degrees occasions a slight combustion, by means of which, the hydrogen, which entered into their
composition

composition is destroyed; they change to a yellow, red, or fawn colour; their attraction for the stuff seems to diminish; they separate from it, and are carried off by water: all these effects vary, and take place more or less readily, and more or less completely, according to the nature of the colouring particles; or rather, according to the properties which they possess, in the state of combination into which they have entered.

The changes which occur in the colours produced by the union of the colouring particles with metallic oxyds, are effects, compounded of the change which takes place in the colouring particles, and of that which the metallic oxyd undergoes.

The light of the sun considerably accelerates the destruction of colours; it ought therefore (if the theory I have proposed be well founded) to favour the combination of oxygen, and the combustion thereby produced.

Mr. Sennebier has given us a great number of interesting observations on the effects of light on different substances, and particularly on their colours; he attributes these effects to a direct combination of light with the substances^r.

^r Mem. physico-chymiques sur l'influence de la lumière solaire, &c. vol. ii & iii.

The effects of light on the colour of wood, have been long since observed ; it preserves its natural appearance while kept in the dark, but when exposed to the light, it becomes yellow, brown, or of other shades. Mr. Sennebier has remarked the varieties which occur in this particular, in different kinds of wood, and has found, that the changes were proportioned to the brightness of the light, and that they take place even under water, but that wetted wood underwent these changes less quickly than that which was dry ; that several folds of ribband were required to defend the wood completely, that a single leaf of black paper was sufficient, but that when paper of any other colour was substituted, the change was not prevented ; a single covering of white paper was insufficient, but two intercepted the action of the light.

That philosopher has extended his experiments to a great number of vegetable substances, in a manner which may serve to illustrate many phenomena of vegetation, which I do not enter into at present. But to shew, in what manner the sun acts upon colours, it may be sufficient to examine the appearances, presented by a solution of the green part of vegetables in alcohol.

If such a solution, which is of a fine green colour, be exposed to the light of the sun, it very soon acquires an olive hue, and loses its colour in a few minutes. If the light be weak, the effect is much more slow; and in perfect darkness, the colour remains without alteration, or if any change does take place, it requires a great length of time. Mr. Sennebier asserts that an alkali restores the green colour; but if the change of colour in the liquor has been completed, the alkali has no effect. He has observed that no change of colour takes place in azotic gas (phlogisticated air) nor in a bottle which is quite full.

I inverted over mercury a bottle half full of this green solution, and exposed it to the light of the sun; when the colour was discharged, the mercury was found to have risen in the bottle, and consequently, vital air had been absorbed, the oxygen having united with the colouring matter. I did not observe that precipitate which Mr. Sennebier mentions; the liquor had continued transparent and retained a slight yellow tinge.

I evaporated this liquor; its colour was immediately rendered darker, and became brown; the residuum was black, and in the state of charcoal.

The light therefore produced its effect by favouring the absorption of oxygen, and the combustion of the colouring matter; at first, the marks of combustion are not evident; the liquor retains only a slight yellow tinge, but by the assistance of heat, the combustion is completed, the liquor becomes brown, and leaves a black residuum. If the vessel in which the liquor is, contains no oxygenous gas, the light has no effect on the colouring matter; azotic gas in this situation suffers no diminution.

The above observation, that ribbands, or a single leaf of white paper, do not prevent the action of light, merits attention, by proving that light can pass through coverings which appear to be opaque, and exert its energy at some distance within.

Beccaria, and afterwards Mr. Sennebier, have compared the effects of light on ribbands of various colours; but the differences they have observed, are rather to be attributed to the nature of the colouring matters, than to the colours, for a ribband dyed with brasil wood, will lose its colour much sooner than one dyed with cochineal, though the shade should be perfectly the same in both.

Although

Although light greatly accelerates the combustion of colouring matter, and appears even necessary to its destruction in some cases, yet in others it is not required. Having put some plants into a dark place, in contact with vital air, I found that it was absorbed by some. I also remarked that the rose suffers a change, and becomes of a deeper hue, when it is not in contact with vital air; doubtless, because it contains a little oxygen, the combination of which becomes more intimate; but many flowers retain their colour perfectly in azotic gas.

I placed tincture of turnsole in contact with vital air over mercury, both in the dark, and exposed to the light of the sun; the former continued unchanged for a considerable length of time, and the vital air had suffered no diminution; the other, lost much of its colour, became red, and the air was in a great measure absorbed, and a small quantity of carbonic acid was produced, which no doubt had occasioned the change of colour from blue to red.

This observation may lead us to form an idea of some of the changes of colour, produced by a particular disposition of the component principles of vegetable substances, when

by their combination with oxygen, they undergo the effects of a slight combustion, which may generate an acid, as in the leaves in autumn, which grow red, before they become yellow, and in the streaks (panachures) observable in flowers, the vegetation of which is growing languid.

It is therefore proved, that light promotes the absorption of oxygen by the colouring matter, and that thence arises a combustion, the common effect of which is, the predominance of carbonic particles.

To the same cause, is also to be attributed the injury which stuffs themselves are found to suffer, from the action of light. “ Among
 “ several examples which I might give, says
 “ Dufay, I shall adduce only one, of a curtain
 “ of crimson taffeta, which had remained drawn
 “ in a window for a great length of time ; all
 “ the parts which were opposite to the panes
 “ of glass, had entirely lost their colour, while
 “ those which were behind the wood of the
 “ casement, were much less faded ; and further,
 “ the silk itself was almost entirely destroyed
 “ in the parts without colour, where the cur-
 “ tain might be torn by the slightest effort,
 “ while in the other parts, it retained nearly
 “ the usual degree of strength &.”

Here an apparent contradiction occurs. The action of the sun's light produces colours in vegetables; it extricates oxygen from the nitric and oxygenated muriatic acids, from some metallic oxyds, and from plants in a state of vegetation: in these instances, its action seems to be the reverse of combustion; but when it contributes to the destruction of colour, it serves to fix oxygen, and produces a kind of combustion. In like manner, phosphorus is not affected by the oxygenated muriatic acid, even assisted by heat, while in the dark; but when the action of light concurs, it is converted into phosphoric acid^h.

I am unacquainted with the circumstances, and the attractions, which determine sometimes the production of one effect, sometimes that of the other, but both of them are equally demonstrated. They seem to bear a resemblance to double elective attractions. It is very certain that calcareous earth yields the sulphuric acid to pot-ash, but yet that calcareous earth is capable of expelling the pot-ash, by means of a double elective attraction.

There are besides in nature a great many phenomena of the same kind; thus, during

^h Mem. sur l'acide marin dephlogistiqué. 1785.

the vinous fermentation, hydrogen is accumulated in the liquor, but by a continuance of the same process, the proportion of hydrogen is diminished; it unites with the oxygen, which becomes predominant, as soon as the fermentation has advanced to the acid stage. The putrefaction too, which takes place in animal substances, may be considered as the reverse of the phenomena of growth and nutrition.

Colouring substances therefore resist the action of the air more or less, according as they are more or less disposed to unite with oxygen, and thereby to suffer more or less quickly, a smaller or greater degree of combustion. Light favours this effect, which in many cases is not produced without its assistance; but the colouring matter in its separate state, is much more prone to this combustion, than when united to a substance, such as alumine, which may either defend it by its own power of resisting combustion, or by attracting it strongly, weaken its action on other substances, which is the chief effect of mordants; and finally, this last compound acquires still greater durability, when it is capable of combining intimately with the stuff.

Thus the colouring matter of cochineal dissolves easily in water, and its colour is quickly

quickly changed by the air ; but when united to the oxyd of tin it becomes much brighter, and almost insoluble in water, though it is still easily affected by the air, and by oxygenated marine acid ; it resists the action of these better however, when it has formed a triple compound with a woollen stuff.

It must not be inferred from the above observations, that all yellow colours are owing to the carbonic part of the colouring substance ; very different compounds are capable of producing the same colour ; thus, indigo is very different from the blue of our flowers, from that of oxyd of copper, and from that of prussian blue.

Nor do I assert, that oxygen may not unite in a small proportion with some colouring substances, without weakening their colour, or changing it to yellow. In the chapter on indigo, it will appear, that it becomes green by uniting with an alkali, with lime or a metallic oxyd ; but that it resumes its colour, and quits these substances, when it recovers a small portion of the oxygen which it had lost. The liquor of the whelk employed to dye purple, is naturally yellowish ; but when exposed to the air, and more especially to the sun, it quickly passes through various shades, and at

length assumes that colour so precious in the eyes of the ancients¹.

It may even be considered as a general fact, that colours become brighter by their union with a small portion of oxygen; for this reason, it is found necessary to air stuffs, when they come out of the bath, and sometimes even to take them out of it from time to time, expressly for this purpose; but the quantity of oxygen, which thus becoming fixed, contributes to the brightness of the colour, is very inconsiderable in some cases, and the deterioration soon commences.

The action of the air affects not only the colouring matter and the stuff, but also metallic oxyds, when they are employed as intermedes; because the oxyds, which have at first been deprived of a part of their oxygen by the colouring particles, as will be shewn when we come to explain the action of astringents, may absorb it again. Those then, the colour of which varies according to their proportion of oxygen, have thereby an influence in changes of colour. It is doubtless to this cause, that

¹ Decouverte d'une nouvelle teinture de pourpre &c. par Reaumur. Mem. de l'acad. 1711. According to Eudocia, the purple did not assume its brilliancy nor arrive at perfection, but by exposure to the rays of the sun.

we are to attribute the change observable in the blue given to wool, by sulphat of copper (blue vitriol) and logwood. This blue soon becomes green by the action of the air; now it is well known, that copper which has a blue colour, when combined with a small proportion of oxygen, assumes a green one, by its union with a larger quantity. The change which the colouring particles undergo, may indeed contribute to this effect; but the colouring particles of the logwood which have themselves a dark colour, should rather become brown by combustion, than grow yellow, which would be necessary in order to produce a green with the blue.

I have observed, that colouring particles in a state of combination, were less disposed to be changed by the action of the air, than in an uncombined state. This is commonly the case, but there are some exceptions; an alkali produces a contrary effect.

I half filled a matrafs with an infusion of cochineal, and exposed it to the light, over mercury; a similar matrafs contained an infusion of cochineal made with a little tartar; and in a third, I had added a small quantity of alkali to the infusion. The second matrafs appeared least altered in the same space of

H 3

time,

time, and in it, the absorption had been least considerable. In the third, the colour of the liquor became first brown, and was then discharged, and the absorption of air, though inconsiderable, was greater than in the two others. I evaporated it; it assumed a brown colour, and left a yellowish brown residuum.

I made similar experiments on many colouring substances; the alkali darkened their colour, which grew more and more brown, and promoted the absorption of air. Madder seemed to be the only exception to this rule; its colour, which became darker at first, stood better, than that of the infusion made without alkali.

The common effect of alkalis on the colouring particles, is consonant to that which it produces on many other substances, such as sulphur; it favours the absorption of air because it has a strong attraction, for the substance which is the result of that absorption.

From this effect of alkalis I explain a fact observed by Mr. Becker^b; that a vegetable infusion rendered green by an alkali, becomes gradually yellow, if left exposed to the air, and that when the yellow is completely formed (*etabli*) acids cannot restore the original colour:

^b Specimen, &c.

but that this is not the case, when a vegetable colour reddened by means of an acid, has been kept in like manner for some time. We must however except those instances in which acids have been employed, which act by giving off their oxygen in a way we shall presently see, for then, the colour is likewise destroyed.

C H A P. IV.

Of the Yellow Colour produced in Animal Substances by the Nitric and oxygenated Muriatic Acids.

THE action of the nitric and oxygenated muriatic acids, upon animal substances, has such a connexion with the preceding subject, that I thought it improper to place them far asunder, though the yellow colour they produce in wool, and more especially in silk, might merit a place among the processes of the art.

Mr. Brunwiser^a having observed that wood

^a Versuche mit mineralischen sauern geistern, aus den holzen farben zu ziehen, 1770, in abhandlungen der Baierischen akademie.

assumed different colours by exposure to the air, endeavoured to ascertain whence those colours proceeded, and to produce them artificially: he observed, that by moistening the surface of wood with nitric acid, particularly that of young wood not yet quite dry, it assumed a yellow colour, and that by performing the same operation, with the muriatic and sulphuric acids, it assumed a violet colour, which he considered as composed of a blue and a red.

From these observations he concludes, that, as all colours are produced by a mixture of yellow, blue, and red, all those which are observed in the leaves, fruits, and flowers, are owing to the colouring particles which exist in the wood, and are there disguised by an alkali; that the mineral acids, by taking up this alkali, set the colouring particles at liberty, and that the fixed air, by penetrating the leaves, fruits, and flowers, produce naturally the same effect, by combining with the alkali which kept them disguised. The author has endeavoured to apply his experiments, and pretended discovery, to the arts ^b. Having moistened pieces of

^b Entdeckung verschiedener vegetabilischen farbematerialien, seiden und wollen zeuge schön und dauerhaft gelb zu färben 1771.

wood with nitric acid, he poured water upon them, filtered the liquor, and employed it to dye stuffs of wool, silk, and goats hair, of a durable yellow, which, in his opinion, is produced by the yellow colouring particles contained in the wood, and extracted, or disengaged by the nitric acid.

De la Folie ^c relates that, having immersed a skein of white silk in nitric acid, or aqua fortis of the strength it is generally met with in commerce, the silk in three or four minutes assumed a fine jonquille yellow. He washed it several times in water, that it might not be affected by any adhering acid; the colour sustained several trials to which he submitted it, and the silk preserved its lustre unimpaired. If it be dipped into an alkaline solution it assumes a fine orange colour.

We find several experiments on this process, in a dissertation by Mr. Gmelin ^d, who says that he has given a fine brimstone colour to silk, by keeping it for the space of a day in cold nitric acid, or some hours only, when the acid was warm. Boiling with soap and

^c Journal de Phys. t. iv. pag. 349.

^d T. Frieder. Gmelin prof. Gotting. de tingendo per nitri acidum, sive nudum, sive terra aut metallo saturatum serico. Erfurti 1785.

water diminished the brightness of this colour. It was changed to a fine lemon colour, by being kept for twelve hours in an alkaline solution, and it assumed a fine gold colour when the solution was employed hot.

All solutions of metals in nitric acid communicated a more or less deep yellow to silk, as did also the solution of alumine in the same acid; but those of calcarous earth and magnesia produced no effect.

According to la Folie*, solution of tin mixed with a solution of gold, gives a purple, which fixes on silk; but Mr. Gmelin obtained in this way, only common yellow. Mr. Gmelin also shews, that the different yellows, which Mr. Struve had said were obtained by different metallic solutions†, depend only on the acid they contain. The only exception, perhaps, occurs in the case of mercury, the solution of which gives silk a copper colour.

Bergman was acquainted with this process, when he published his notes on Scheffer's treatise‡: He says that common aqua fortis gives wool and silk a clear, beautiful, and

* Journ. de Phys. t. viii.

† Bernerisches magazin der naturhunst und wissenschaften, vol. i.

‡ Essai sur l'art de la Teinture.

durable yellow, in three or four minutes; that they ought to be washed immediately, and that the more the acid is *dephlogisticated*, the greater is the effect produced.

In my earliest experiments on oxygenated muriatic acid, I found that it also had the property of tinging animal substances yellow; but it does not give them nearly so deep a colour as the nitric acid does, and it weakens them much more than that acid properly diluted; so that for the purposes of art, the nitric acid is greatly preferable.

To recapitulate these observations then, the nitric acid diluted with a certain quantity of water gives silk a yellow colour, which is more or less deep, according to the concentration of the acid, its temperature, and the time of immersion; the silk must be carefully washed as soon as taken out of the acid: this colour possesses considerable brightness; it may be made deep without sensibly weakening the silk, so that this process may prove of real utility. The colour may be modified by alkalis.

The solutions of calcareous earth and magnesia produce no effect upon silk, because they do not contain an excess of acid; the solution of alumine and of all metallic substances, on the contrary, produce a more or less deep yellow, because

because they all contain more or less excess of acid, which acts upon the silk, like uncombined acid; it was also the acid alone, which dyed the animal substances yellow in Mr. Brunwiser's experiments, and not the matter extracted from the wood.

The yellow colour in these cases, is not owing to iron, as de la Folie supposed; for the purest nitric acid, which consequently contains no iron, produces it, as well as that, in which the presence of that metal might be suspected.

If silk be put into concentrated nitric acid, it quickly assumes a deep yellow colour, loses its cohesion, and is dissolved; during this solution, the azot (phlogisticated air) which enters into the composition of animal substances, is extricated, with a long continued effervescence^b: if heat be applied, it expels much nitrous gas, and the liquor immediately acquires a deep colour and grows brown. At this time, the oxygen of the nitric acid certainly combines with the hydrogen, which abounds in animal substances, forming the oil which is obtained from them by distillation, and which renders them so inflammable. When

^b Mem. de l'acad. 1785.

the acid begins to act and to render the silk yellow, the same effect should also begin to take place. I therefore suppose that the yellow colour arises from a commencement of combustion, as explained in the preceding chapter. This combustion being very slight, does not sensibly weaken the silk; but if the acid is a little too strong, or the immersion too long continued, or if the whole of it is not carried off by careful washing, the silk immediately becomes weak, and in vulgar language, which is here quite accurate, it is *burnt*.

We therefore now see, why, as Bergman observed, the nitric acid which he called dephlogisticated, is preferable in this operation, to that which is saturated with nitrous gas; for in the former, the proportion of oxygen being greater, it is thence better fitted for producing the effects of combustion, until it is reduced to the state of nitrous acid.

The same explanation ought doubtless to apply to the action of the oxygenated muriatic acid, on animal substances; it differs however in some essential circumstances, some of which I do not yet understand, and which require a greater number of observations.

Silk takes a yellow which is much lighter, when the oxygenated muriatic acid is employed,
than

than when the nitric acid is used: the sulphureous acid discharges it in a great measure, but has no effect on the yellow produced by the dilute nitric acid. The oxygenated muriatic acid has however, a much stronger action on the silk; it soon weakens, and even dissolves it: if the silk be left for some time in this fluid, the yellow which at first appeared grows lighter; in conformity to what I have remarked, that oxygen by being accumulated, is capable of disguising the yellow colour occasioned by the combustion, which it had at first produced.

I have endeavoured to explain the effects which sulphureous acid produces on colours, by the facility with which it gives off its oxygen, and have compared them to those of the oxygenated muriatic acid; but although it is true, that oxygen adheres much more weakly to the sulphureous, than to the sulphuric acid, I do not believe that that explanation is well founded.

According to the observation of la Folie^k, roses whitened by the vapour of burning sulphur, become green in an alkaline lixivium,

ⁱ Suite des exper. sur l'acide sulfureux. Ann. de Chym. t. ii.

^k Journ. de Phys. 1774.

and red in acids; I have myself observed, that the sulphureous acid reddened the tincture of turnsole, which has a very fading colour, and that it acted only like other acids on infusions of fustic, brazil wood, and logwood. I have further observed, that silk which has been exposed to the vapour of sulphur, exhaled the smell of sulphureous acid, when moistened with sulphuric acid, although that odour was not before perceptible.

I conceive then, that the sulphureous acid commonly unites with the colouring particles, and with the silk, without giving off its oxygen to them, and consequently, without producing any combustion; that the product of that combination sometimes loses its colour entirely, which is probably owing to the semi-elastic state of the oxygen; but sometimes combustion may, and even commonly should take place by degrees, so that the colouring particles, which have long been disguised, ought at last to leave a yellow colour. This point seems capable of being easily cleared up by a few experiments.

C H A P. V.

Of Astringents in general, and particularly of the Gall-nut.

ASTRINGENTS merit particular attention, not only from their great use in dyeing, but because they possess a property which is common to a great number of vegetables.

There is perhaps no property of vegetables, respecting which, we have been contented with such vague ideas: frequently some slight resemblance in taste only has been attended to, and under the name of astringents, alum, and many vegetables of very different properties have been confounded together, both in medicine and in the arts: most frequently every substance which renders a solution of iron black, has been considered as astringent; it is supposed that this effect is owing to one identical principle existing in all the substances which produce it, and the title astringent or acerb, has been bestowed on that principle, and it is at present considered as a particular acid, to which, the name of gallic acid has been
given,

given, from galls or the gall-nut, in which it has been found.

Many learned chemists however, have lately made a great number of interesting observations on astringents; of these I shall give an abstract, but as the gall-nut has been the common subject of these observations, it ought first to be described.

The gall-nut is an excrescence found on the young branches of the oak, especially of that kind called *rouvre*, which grows in the Levant, Istria, Provence, and Gascony. This excrescence is produced by the puncture of an insect, which deposits its eggs in the small incision, which it makes in the spring; the sap which escapes by this opening, grows thick, increases in quantity, and serves as a defence for the young insect, until it is able to make its escape; when there is no hole in the nut, the insect is found dead within; sometimes after it has quitted its abode other insects come to occupy it.

There are different kinds of the gall-nut; some inclining to white, yellow, green, brown, or red; others are ash-coloured or blackish; they also differ greatly in magnitude, and are either round or irregular, heavy or light, smooth or covered with protuberances: those which

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are small, blackish, knotted, and heavy, are the best; they are known by the name of Aleppo galls, and come from Aleppo, Tripoli, and Smyrna.

Galls are almost totally soluble in water by long ebullition, sixteen drams afforded Neuman fourteen of extract; from the remaining two drams, alcohol extracted only four grains.

The same quantity treated first with alcohol, and then with water, afforded twelve drams and two scruples of spirituous extract, and four scruples of watery extract; the residuum weighed half a scruple more than in the preceding experiment. The spirituous extract has a more strong and disagreeable taste than the other ^a.

Mr. Monnet, to whom chemistry is indebted for a great number of important observations ^b, considers Macquer as the first, who ascribed the formation of ink to a precipitation of iron, by the astringent principle, and he himself gives the theory of it; he supposes that the iron has a greater attraction for this principle, than for the acid with which it was

^a The chemical works of Caspar Neuman, &c. by William Lewis.

^b *Traité des eaux minerales*, pag. 304.

united; but the acid dissolves a part of this precipitate, unless it be largely diluted with water.

Iron is not the only metallic substance which may be precipitated from its menstruum by the astringent principle; Mr. Monnet has observed, that gold, silver, copper, zinc, cobalt, platina, and mercury, were also precipitated.

The metallic substance most easily precipitated is mercury; its solution, mixed with an infusion of galls, assumes a brick colour, but the precipitate which is formed, soon becomes of a reddish gray.

Copper is precipitated pretty easily; the precipitate is at first green, but becomes of an ash gray, and acquires a reddish coppery tinge in drying.

Zinc forms a dirty green precipitate.

The precipitate from cobalt is of a light blue: but does not long retain that colour, becoming soon of an ash gray.

Silver is precipitated very slowly; the precipitate which has at first the colour of roasted coffee, assumes a shining silvery brightness, as it dries on the filter.

Gold also falls down, only insensibly; the precipitate collected and dried, perfectly resembles that of Cassius. Mr. Monnet collected on a filter the precipitate of iron by

the astringent principle, it was found to be of a fine deep blue and that chemist is of opinion, that it might be advantageously employed in painting. He endeavoured to dissolve it in the nitric and sulphuric acids; they attacked it but slowly: having accelerated their action by heat, he obtained by filtration, fine yellow tinctures (particularly from the nitric acid) which resembled a solution of gold. These liquors let fall no precipitate, but remained always clear and transparent; alkalis occasioned no precipitation in them, but only rendered their colour deeper. Mr. Monnet was led, by observing this, to dissolve the precipitate immediately in a solution of fixed alkali, in which he made it boil; a blood red solution was produced, in which water occasioned no precipitation. To these facts, the academicians of Dijon have added many interesting observations^c.

The gall-nut yields, by distillation, a limpid phlegm, which becomes brown by degrees, then a yellow oil, and afterwards one that is more dark coloured and empyreumatic. All these liquors precipitate sulphat of iron or vitriol of a black colour, the coaly residuum retains no distinct properties; it grows red in the fire without being reduced to ashes. Water even

^c Elem. de Chym.

in the cold, dissolves the astringent principle; an ounce of galls yielded in this way three drams of extract, which was very styptic, and not deliquescent.

Fixed and volatile oils and ether, dissolve the astringent principle.

Infusion of galls reddens blue paper, and tincture of turnsole^d; but it has no effect on syrup of violets.

Sulphuric acid acquires a red colour from galls; the nitric, an amber colour; and the muriatic acid becomes brown; these three acids when saturated with an alkali, precipitate sulphat of iron black.

The acetous acid, loaded with the astringent principle, does not require the addition of an alkali to produce this black precipitate.

Phosphoric acid produces no change in the infusion of galls, but this mixture renders the solution of sulphat of iron turbid, and produces a white precipitate.

Sulphuret of alkali (alkaline liver of sulphur) is decomposed by the infusion of galls; and upon filtering the liquor, that which passes, precipitates iron black, but the residuum does not; the liquor appears to be a compound of alkali and the astringent principle.

^d I also found that this infusion reddened that of radishes.

Carbonat of fixed alkali (mild fixed alk.) produces a reddish colour in the infusion of galls; this mixture forms a brown precipitate with sulphat of iron.

Caustic alkali tinges the infusion of galls of a dark red, and then precipitates the sulphat of iron black; this precipitate, when well washed, is not attracted by the magnet; it dissolves without effervescence in the mineral acids, but is not acted upon by the acetous acid.

A mixture of prussiat of alkali, and tincture or alcohol of galls, produces a black precipitate with the solution of iron; sulphuric acid at first increases the intensity of the colour, and afterwards destroys it.

The same work contains a great number of other observations upon the metallic precipitates produced by the astringent principle. Galls produce no effect on the solutions of arsenic, and the addition of this oxyd to the infusion of galls, does not prevent its action on iron. The astringent principle forms ink with all acid solutions of iron, except those in the phosphoric and arsenical acids.

Finally, we find in it some experiments on ink, and on the sediment it yields, by large dilution with water. The acetous acid does not decompose ink, but the mineral acids quickly discharge its colour, the addition of sulphuric acid

acid produces heat, without effervescence; the liquor becomes yellow, and deposits a grayish sediment. Alkalis restore the colour which the acids have discharged; but, by frequent alternation of the action of acids and alkalis, the colouring principle is at length destroyed.

The same academicians have also observed another circumstance, which may be found to be of importance, and to which it appears, that Mr. Delaval has paid more attention; it respects the action of galls on iron. Their infusion imparts a violet tinge to filings of iron in the cold; but, by ebullition, part of the iron is dissolved, and the liquor assumes a violet colour strongly inclining to black.

Mr. Delaval^e says, that he had long ago observed, that galls simply infused in distilled water, dissolved iron very readily; that he had produced with this simple solution, not only the deepest black and the most indelible ink, but also, that having immersed in it silk and woollen stuffs, he had, without the addition of any acid, dyed them of the deepest and most indestructible black.

Dr. Priestley obtained inflammable air, or hydrogenous gas, from a mixture of filings of

^e Experimental inquiry.

iron, powdered galls and water^f. This proves that galls act upon iron, like those acids which favour the decomposition of water, and disengage its hydrogenous gas.

Before Mr. Monnet ascertained the manner in which the astringent principle acts upon iron, and produces black colouring particles, capable of precipitation, Lewis had made some important observations on this combination^g, and had endeavoured more particularly to render it useful in the arts.

He observes, that if we dilute common ink with a sufficient quantity of water, the black part precipitates, and the liquor remains clear; he remarks that it is this black part, which, fixing in stuffs, produces colour in them. He endeavours afterwards to determine the fittest proportion of the astringent, and solution of iron, both with a view to the quantity and quality of the black precipitate.

The experiments of Scheele have so great an influence on the opinion formed respecting the nature of the astringent principle, that I shall relate them as delivered by himself^h.

^f Observations on different branches of natural philosophy, vol. ii. page 131. Of the new edition in 3 vols. 8vo. Birmingham, 1790, page 194. T.

^g Philosophical commerce of arts, vol. ii. page 227.

^h Journal de phys. janvier 1787.

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“ I passed through a coarse sieve a pound of powdered galls, which I infused in a kanne (two pints and three quarters french, nearly three quarts english) of pure water in a glass receiver, for four days, during which time it was frequently stirred with a glass rod; I then filtered the liquorⁱ, which was clear and of the colour of french wine, I left it exposed to the open air in the same glass vessel, with no other covering than a piece of gray paper; this was done in the month of June. A month after, I examined the infusion, and found it covered with a thick mouldy pellicle; no precipitation had taken place, its taste was not more astringent than before, but more acid: I returned it into the same vessel, covered with paper as before. Five weeks after, I examined it again; the half of it had evaporated: I found in it a precipitate, two fingers breadth in depth; and above, a mucous pellicle; it had lost its styptic taste entirely, but still made vitriol of iron black. I filtered it, and exposed it again to the open air; the following autumn, it was found, that the greatest part of it had evaporated; but what remained, was mixed with a considerable quantity of precipitate. I mixed

i “ If we employ hot water, or digest the mixture with heat, the fluid is not clear, which determined me to employ cold water, and infusion in the cold.”

all the precipitates together, and added cold water; after they had settled, I decanted the water, and poured on as much hot water as was necessary for their solution: I filtered the whole; the liquor was of a yellowish brown colour; I evaporated it with a gentle heat; during the evaporation, some part of it was precipitated like fine sand, and another part formed radiated crystals at the bottom; this salt was gray, and notwithstanding repeated solutions and crystallizations, I could not make it any whiter.

The salt of galls has the following properties:

1. Its taste is acid, it effervesces with chalk, and reddens the infusion of turnsole.

2. It requires an ounce and a half of boiling water for the complete solution of half an ounce of the salt; but as soon as the solution cools, the whole forms a concrete mass composed of small crystals; half an ounce requires twelve ounces of cold water for its solution.

3. It dissolves very readily in spirit of wine; for half an ounce of the salt, only half an ounce of boiling spirit of wine is required; but if cold spirit of wine be employed, two ounces are necessary to half an ounce of the salt.

4. Exposed to the naked fire in a crucible, it takes fire readily and melts, exhaling an agreeable odour, but leaves a coal which is
difficultly

difficultly reduced to ashes; distilled in a retort, it first becomes fluid, yielding an acid phlegm; no oil comes over, but at last a white sublimate rises, which adheres to the neck of the retort, and remains fluid while it continues hot, but afterwards crystallizes; a considerable quantity of charcoal remains in the retort. This sublimate, as to its smell and taste, nearly resembles the benzoic acid, or salt of benzoin; it is soluble both in spirit of wine and water, it reddens the infusion of turnsole, and what is remarkable, it precipitates metallic solutions of different colours, and vitriol of iron black.

5. A solution of the salt of galls poured into a solution of gold, renders it of a dull green colour, and at length precipitates a powder, which is revived gold.

6. The solution of silver becomes brown, and deposits, when heated, a gray powder, which is revived silver.

7. The solution of mercury is precipitated of a deep yellow.

8. The solution of copper affords a brown precipitate.

9. The solution of vitriol of iron becomes black; the more the water is loaded with it, the deeper is the colour.

10. Lead

10. Lead dissolved in vinegar, is precipitated white.

11. Bismuth affords a lemon-coloured precipitate.

12. The molybdic acid becomes of an obscure yellow, but no precipitation takes place.

13. Platina, zinc, arsenical acid, tin, cobalt, and manganese, suffer no change.

14. Solutions of lime, magnesia, alumine, and barytes, are not decomposed; but lime water affords an abundant gray precipitate.

15. The salt of galls is changed into saccharine acid, by distillation with nitrous acid in the ordinary way.

The white precipitate obtained from acetated lead by galls, may again be decomposed by the vitriolic acid, and the salt of galls is obtained in its greatest purity: now, as infusion of galls precipitates acetated lead, I thought this salt might be procured in a still more expeditious way; but I did not succeed, for when I had decomposed that precipitate by means of the vitriolic acid, I recovered my infusion of galls with its ordinary astringent taste.

If galls be distilled with a strong heat, we obtain an acidulous phlegm of by no means a disagreeable smell; no oil comes over, but at

length a volatile salt arises, like that obtained in the distillation of the salt of galls (No. 5) and which has the same properties. Hence it appears, that this salt exists ready formed in the infusion of galls, though it cannot be obtained by the ordinary mode of crystallization, for it is so intimately united with some mucilaginous principle or other matter, that it cannot be separated, without an internal commotion or fermentation."

These experiments of Scheele have led most chemists, to consider the gallic acid as the astringent principle, and to conclude, that it exists in all vegetable substances which precipitate the solutions of iron black, and that this precipitate is a compound of the gallic acid and the iron, which quits the other acids to unite with it.

I have repeated and varied Scheele's experiments on galls, and have observed,

1. That when the process indicated by that great chemist was employed, greenish pellicles were formed in succession, owing to a byssus which could not be produced in a vessel closely stopped.

2. That in such a vessel, where no evaporation could take place, pure, transparent, and yellow crystals were deposited in winter, without
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the influence of the external air; that consequently the gallic acid existed in the gall-nut, and was not owing to the absorption of oxygen, as I had supposed^k.

3. That if the liquor was evaporated to one half before being enclosed in the vessel, it acquired a dark colour during evaporation, and deposited afterwards a much larger quantity of crystals, but less pure and of a darker colour.

4. That the acid obtained in this manner, or by Scheele's process, and afterwards dissolved in water, was always decomposed by evaporation; that black pellicles were separated from it, that it grew brown by simple exposure to the air, that after repeated operations, only a mass of a confused crystallization was obtained, of a gray, yellowish, or brownish colour, and that if the evaporation was frequently repeated, the salt was even totally destroyed. Heat, and particularly ebullition, hasten this destruction; this I conceive to be the true reason why we do not obtain this salt, by evaporating the decoction of galls; there then remains an extract, which completely resembles that of galls, and which immediately precipitates solutions of iron black.

5. The solution of gallic acid assumed a fine green colour with alkalis, both fixed and volatile,

^k Ann. de Chym. tom. i.

in their pure state, or combined with the carbonic acid, and this colour becomes so deep, as to appear black, if the solutions of gallic acid and alkali are in a very concentrated state: the gallic acid assumed a reddish brown colour with lime water; the red tinge disappeared, and a copious sediment of a gray colour inclining to brown, was produced.

I observed no effervescence in the mixture of gallic acid with alkaline carbonats, nor with those of lime, or magnesia; though this substance reddens tincture of turnsole, of radishes, &c. like acids.

6. The infusion of common galls produces the same effect on vegetable colours, that the gallic acid does, but the infusion of white galls has no action on them.

Paper stained with turnsole was not affected by infusion of sumach, of floe or walnut-tree bark, or quinquina.

Having made four successive decoctions of galls, which had previously been treated in the manner recommended by Scheele, the two last did not redden paper stained with turnsole, though they still precipitated iron copiously from its solutions. From these two last decoctions I obtained no marks of gallic acid by spontaneous evaporation.

7. A solution of sulphat of iron, mixed with a solution of gallic acid reduced to as great a degree of purity as possible, does not grow turbid immediately, nor assume any particular colour; it only becomes black by degrees, without losing its transparency, or at least, it does not begin to lose it for some hours: a small quantity of the infusion of galls instantly produces a much more intense colour and greater opacity.

These observations indisputably prove, that it is not the gallic acid, which communicates the astringent property to the substances that possess it; that the acid itself possesses that property, in a degree inferior to other astringents; and indeed sumach, treated like the galls in Scheele's process, afforded me no gallic acid, though it possesses a high degree of astringency: walnut peels treated in the same manner also afforded none.

It appears that the property which the infusion of common galls has, of reddening certain vegetable colours, proceeds only from the gallic acid; since the infusions of sumach, or of floc bark, which very readily produce a black precipitate, that of walnut-tree bark, or of quinquina, did not exhibit this property; and thence it is evident, that the gallic acid does
not

not exist in white galls; though the infusion of these exposed to the air, might easily deceive us in this respect, because it deposits a copious sediment, which however is not gallic acid.

If the astringent property was owing to an individual principle, which was always the same, distributed in different vegetables, the precipitates obtained by their means, from a solution of iron, would always form the same compounds, and exhibit the same appearances and properties; but it is quite otherwise: the precipitate produced by galls, is of a blackish blue, that by logwood, has a different shade of blue; that by oak is of a fawn colour or blackish brown; that by quinquina a blackish green; they fall down with different attendant circumstances, and when fixed on stuffs are discharged by alum and tartar, some much more easily than others; and doubtless by multiplying experiments, many other remarkable differences will be discovered in the properties of these different precipitates. Astringents then form with iron different species of compounds, and consequently, do not derive their properties from one individual principle found in different vegetables; but there must be a property common to different substances, to enable them to act in an uniform manner

on solutions of iron, and to produce precipitates which are more or less black, and appear of the same nature when not attentively considered.

I have observed, when investigating the effects of mordants, that the metallic oxyds which unite with the colouring particles, modify their colours; but some metallic oxyds, and particularly that of iron, have colours which vary according to the quantity of oxygen they contain. Iron when united with only a small quantity of oxygen, has a black colour, and forms what is called *martial ethiops*. If any substance by uniting with the oxyd of iron, had the property of taking from it a part of the oxygen which it has, when precipitated from its solution in an acid, this would be sufficient to give it a black colour; and if the peculiar colour of this substance was not predominant, or was of itself inclining to black, the compound formed would have a black colour, thus nitrous gas, either uncombined or weakly attached to the nitrous acid, renders solutions of iron black, as I have shewn¹, and even precipitates the metal, by taking away part of its oxygen.

It

¹ Mem. de l'acad. 1785, p. 338. The cause of the production of black by the gallic acid, has not escaped the sagacity

It is also by acting in the same way, that ammoniac is capable of producing a black precipitate with the solutions of iron; the hydrogen of the ammoniac then forms water, with the oxygen separated from the oxyd of iron.

Now galls, according to the observations of Mr. Monnet and the academicians of Dijon, which have been already related, precipitate gold and silver from their solutions, by reducing them to their metallic state. They therefore have the property of separating the oxygen from those metals, to which it adheres but slightly, and from others, that portion which is least strongly retained.

The infusion of galls, of itself, quickly assumes a deep brown colour by exposure to the air; yet I have found that it absorbed but a small quantity of vital air. The infusion of sumach, and that of most other vegetable substances, particularly woods and barks, likewise acquire a dark colour by exposure to the air, so that when acting upon the oxyd of iron by separating a part of its oxygen, an astringent

city of Mr. Fourcroy, *it tinges iron black, says he, because it brings it near to its metallic state.* Elem. de Chym. t. iii. pag. 243.

ought itself to acquire a darker colour, which should assist the-black.

We see then in what manner, various substances, which have in other respects different properties, may produce black with solutions of iron. Among these substances, there are some which are real colouring particles, and employed as such, in dyeing; for example, log-wood, and even most kinds of colouring particles, form brown or blackish precipitates with iron. Sometimes the astringent effect is not instantaneous, but produced by degrees, and the colour of the precipitate is at first light; it grows deeper gradually, being darkened in proportion as the iron loses its oxygen; this is observable in the infusion of fustic, which produces with the solution of iron, a yellow precipitate that grows brown by degrees, and at length becomes black.

Although the property of precipitating solutions of iron black, does not indicate the presence of the same individual principle in the substances which possess it, yet there is no inconvenience in calling it by the name of astringent principle, provided we convey by that term, only a property which is common to a great number of substances, and which they may possess in different degrees.

The

The astringent principle precipitates iron from almost all acids: it appears from the experiments of the Dijon academicians, that the acids of phosphorus and arsenic only, have a stronger attraction than it has, for iron; and phosphoric acid was known to have the property of separating iron from the sulphuric acid; but all acids except the acetous, and probably some other vegetable acids which have not been tried, redissolve the precipitate, and make the colour disappear, until they are saturated with an alkali. We need not be surprised, that the astringent principle can unite with metallic oxyds without having the qualities of an acid, for animal substances, oils, even alkalis, and lime, possess this property.

It is the precipitate composed of iron and the astringent principle, which by remaining suspended in the liquor forms ink; this subject is sufficiently interesting in itself, and by its connexion with the black dye, to merit a short digression.

When a small quantity of a solution of iron is poured into an infusion of galls, the liquor at first grows black at the points of contact; but the precipitate which has been formed, is redissolved in the astringent liquor, but by continuing to add enough of the solution of

iron, the whole of the liquor grows black, and loses its transparency: if in this state, it be very largely diluted with water, the precipitate falls down by degrees; but the deposition goes on very slowly, when only a small portion of solution of iron has been employed; but on the contrary, it proceeds much more rapidly, if so large a quantity of solution of iron has been added, that the whole of the astringent may enter into a state of combination, a superabundance of sulphat of iron still further accelerates this effect.

Here we remark the same phenomena that are observable in many other precipitations. The precipitate produced, is soluble to a certain degree in the astringent liquor; when the solution is further advanced, a precipitation commences; but the precipitate still remains suspended, until the action of the astringent principle is sufficiently weakened by the addition of water: if the iron be in sufficient quantity to exhaust the action of the astringent principle, the precipitate is not retained, and falls down much more quickly.

The gum which is added to ink, opposes the deposition of the colouring particles; it serves the purpose, of applying a greater quantity of these colouring particles on the same stroke of
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the pen, and of hindering it from running, and defending it from the action of the air. According to Lewis, cherry or plumb-tree gum answers this purpose, as well as gum arabic.

The principles which I have laid down, serve to explain many observations which Lewis has made on this subject, the chief of which I shall now mention.

The ink which is made by simple infusion, is pale and grows black only by keeping; but if we wish to produce a black ink immediately, we must imitate the dyers, who boil their astringents a long time in water, and then add sulphat of iron: first, by boiling we dissolve much more of the astringent principle: secondly, by adding sulphat of iron to the liquor while it is still very hot, we much more quickly obtain an effect analogous to a slight combustion, which takes place by the union of oxygen with the astringent principle.

Fresh ink, as well as newly dyed stuffs, always acquires a deeper black by exposure to the air; the reason of this seems to be, that the oxygen which galls are capable of separating from the iron, is not sufficient to produce in them the degree of combustion, requisite for making them contribute as much as possible to blackness; and that this combustion is com-

pleted by the oxygen which they attract from the atmosphere.

The ink in which a large proportion of sulphat of iron has been employed, soon grows brown, by the action of the sun and air, and at length becomes yellow, because the iron which is not saturated with the astringent principle continues strongly to attract the oxygen, and thereby loses its black colour, acquiring one inclining more and more to yellow, while at the same time the combustion of the astringent principle goes on rapidly, particularly with the assistance of the light; but the ink is much more durable, if the astringent principle be in sufficient quantity. The best ink according to Lewis, is composed of three parts of galls and one of sulphat of iron. He found, that by moistening writings which had grown brown or yellow, with infusion of galls, their colour was restored. Dr. Blagden employed with success, prussiat of alkali to restore writings which age had rendered illegible^m, and found it more useful than galls.

Although chemists have considered the astringent principle as always the same, experience had taught us, that all astringent substances were not equally proper for producing a beau-

^m Journ. de Phys. mars. 1788.

tiful and durable black ; it is of importance to ascertain which of them may be employed with success ; but it must be observed, that it is very difficult to make comparative experiments on this subject with perfect accuracy, because some substances require much longer boiling than others to extract their astringency ; because a difference in their coarseness or fineness, when subjected to ebullition, is sufficient to produce differences in the results ; and because the colouring particles have a greater or less disposition to combine with the stuff, according to the proportion of sulphat of iron which has been employed.

It must also be observed, that solutions of iron in different acids, may produce differences in the results, according to the state of oxygenation of the iron in them, according as the proportion of that metal is greater or less, and according to the strong or weak action, which the different acids when disengaged, are capable of exerting on the newly formed compound. Finally, in the dyeing of a stuff, its greater or less attraction for the colouring particles may also occasion differences in the results.

Lewis has observed, that a decoction of logwood employed, instead of simple water,

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for the infusion of galls, increased the beauty of ink without rendering it paler; sumach, floe tree, or pomegranate bark, pomegranate flowers, bistort, or tormentil root, and oak bark were not so powerful as galls. In his experiments on dyeing, he found that sumach, oak bark, or the saw-dust of that wood, could not supply the place of galls without being employed in much greater quantities.

Mr. Beunie has published a great number of interesting experimentsⁿ, the object of which was, to determine the best process for giving cotton a durable black. He first tried, what solution of iron gave the finest black to galled cotton; he afterwards combined different solutions, and examined the durability of the blacks which he produced; and made the same experiments on galled cotton, with other metals and semimetals; he employed in like manner, a great number of astringents, and tried with them cotton which had received different preparations. The processes to which these numerous experiments have led, will be found in that section of the second volume which treats of the black dye.

ⁿ Mémoire sur la teinture en noir, qui a remporté le prix de la société de Bruxelles en 1771. Rotterdam 1777.

Of twenty-one species of astringents, compared with galls; oak saw-dust, the galls of the country, and yellow myrobolans, were the only substances which produced a fine black, but which was still neither so fine, nor so durable, as that obtained by means of the common gall. He found that the oak saw-dust was preferable to the bark, which is employed by the dyers of thread, and he observes that it is cheaper.

Messrs. Lavoisier, Vandermonde, Fourcroy, and I, were desired to try experiments on the different astringents, for the purpose of making a report to the academy. The substances upon which we thought it proper to institute experiments of comparison, are galls, oak bark, raspings of heart of oak, of the external part of oak, of logwood, and sumach. To determine the portion of astringent principle contained in these substances, we took two ounces of each separately, which we boiled half an hour in three pounds of water; after the first water we added a second, which underwent a similar ebullition, and continued these operations until the substances appeared exhausted: we then mixed together the decoctions we had successively obtained. We made use of a transparent solution of sulphat of iron, in which
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we knew exactly the proportions of water and sulphat. We first estimated the quantity of the astringent principle, by the quantity of sulphat which each liquor could decompose, and afterwards by the weight of the black precipitate which was formed. In order to stop precisely at the point of saturation, we must proceed very slowly in the precipitation, and towards the end add the solution of sulphat only drop by drop, and cease at the moment when the last added quantity, no longer augments the intensity of the black colour. When the liquor is too opaque to allow its shade of colour to be distinguished, a small quantity of it is largely diluted with water, and by adding to this, a little of the solution of sulphat of iron at the end of a glass tube, it is discovered whether or not the point of saturation has been attained: if we then wish to get the precipitate which is formed, the whole must be largely diluted with water.

This operation merits attention, as being an easy and accurate mode for manufacturers to determine the proper proportions of astringents, and solutions of iron.

To saturate the decoction of two ounces of galls, three drams and sixty-one grains of sulphat of iron were required; the precipitate
when

when collected and dried, weighed seven drams, twenty-four grains.

The decoction of oak bark is of a deep yellow ; a very small portion of sulphat of iron gives it a dirty reddish colour, and a larger one changes it to a deep brown. The quantity of sulphat required to saturate the decoction of two ounces of this bark, was eighteen grains. The precipitate collected and dried, formed coarser and more compact grains, and weighed twenty-two grains ; the inner bark of the oak afforded very nearly the same result.

The decoction of the raspings of the heart of oak, required for its saturation, one dram, twenty-four grains, and the precipitate weighed one dram, twenty-four grains ; the decoction of the external wood of the oak produced very little precipitate.

The decoction of sumach acquired a reddish violet colour when a small quantity of the sulphat of iron was added. The quantity required for its saturation was two drams, eighteen grains. An accident prevented us from ascertaining the weight of this precipitate ; it perfectly resembled that afforded by the galls.

The decoction of logwood became of a sapphire blue colour, by the addition of sulphat
of

of iron: if we go beyond the point of saturation, the blue becomes greenish and dirty. The exact quantity required for saturation was found to be one dram, forty-eight grains, and the weight of the precipitate was two drams, twelve grains. All the precipitations by means of oak take place readily; that by logwood a little more difficultly, but still more easily than that by galls.

We then ascertained by trials made with cloth, that the quantity of astringent substances required to give a black colour of equal intensity, to an equal weight of the same cloth, was proportional to the quantities of astringent principle, which we had already estimated in each kind from the foregoing experiments; but the black obtained by means of the different parts of the oak, does not resist *proofs* or tests of colour (*debouilli*) nearly so well as that produced by galls.

It does not appear that logwood alone is capable of producing so intense a black as galls or oak; and besides, the colour which it produces does not stand the test of proofs so well as that produced by galls.

In the memoirs of Stockholm for the year 1663, it is said, that we may substitute for galls
the

the uva urfi gathered in autumn, and dried carefully, so as to preserve the leaves green.

The theory I have given respecting astringents, is very far from being complete in all its parts; but it establishes principles, which may afterwards be applied by means of experiments, which should be much more numerous and accurate than those that have been hitherto tried. We ought however to confine ourselves in this respect, to the examination of the principal astringents, because most vegetables possess more or less of the astringent property, as may be seen by the experiments of Bergius^o and Mr. Durande^p.

After having considered the astringent principle, with respect to its affinities with solutions of iron, it ought also to be considered, with respect to its property of combining with vegetable and animal substances, particularly the latter. Silk acquires by galling (*engallage*) which consists in macerating a stuff in a decoction of galls^q, a weight which cannot be

^o Materia medica e regno vegetabili.

^p Mem. sur les parties astringentes indigenes. Acad. de Dijon, 1783.

^q I shall apply the term galling to the operation by which an astringent is combined with a stuff, whatever may be the nature of the astringent, or species of stuff.

taken from it, or diminished beyond a certain degree by repeated washing; after which operation, the stuff when put into a solution of iron is dyed black, because the astringent principle, decomposing the sulphat of iron, forms a triple compound with the oxyd of iron and the stuff.

A galled stuff is likewise capable of combining with other colouring particles, the colours of which thereby acquire fixity, if they do not naturally possess it; so that the astringent communicates its durability to the triple compound, or perhaps the more complex one which is formed; but the colour commonly becomes deeper by this union.

The astringent principle by combining with animal substances, renders them incapable of corruption, and tends to render their texture more compact; in this the art of tanning consists, which is the basis of the preparation of leather.

The prize lately offered by the academy of sciences relative to this important art, will undoubtedly procure us great information, and increase its progress; but I hope that the conjectures I had formed will not be useless to those engaged in the subject.

An ounce of galls distilled with a strong heat, yielded three drams of charcoal; an ounce of sugar, two drams, twelve grains; an ounce of the colouring particles of flax, two drams, twenty-four grains; an ounce of dry plumb-tree, one dram, forty-eight grains; an ounce of dry walnut-tree, also one dram, forty-eight grains; so that galls yield almost double as much charcoal as hard and dry wood. I have elsewhere remarked*, that when an infusion of galls or of sumach was decomposed by means of oxygenated muriatic acid, a copious precipitation of charcoal took place, especially in the former.

In consequence of these observations, I consider the abundance of charcoal, as the essential characteristic of the astringent principle; the hydrogen which it contains only in small quantity, is however very much disposed, partially to combine with oxygen; hence it is, that when an infusion of galls is left in contact with vital air, a small quantity of the air only is absorbed, and yet the colour of the infusion becomes much deeper; for in conformity with the theory laid down in Chap. III. and more particularly in the annals of chemistry, the

* Ann. de Chym. tom. vi. • Ibid.

charcoal readily becomes predominant, in consequence of the flight combustion, and the colour grows deeper and becomes brown.

A substance that contains much charcoal, and can undergo only a flight degree of combustion, ought to possess considerable durability, because charcoal does not combine with oxygen in the ordinary temperature of the air, unless its union be assisted by other attractions, and because flight variations of temperature produce no change in the dimensions of charcoal ; on the contrary, substances which contain much hydrogen, and in which the particles of the hydrogen are in a state of division, ought to be easily decomposed, by the combination of the hydrogen with azot or oxygen. The disunion of their parts ought to take place from small variations of temperature, because hydrogen is dilatable by heat, which the carbonaceous particles are not ; agreeably to this, Mr. Monge ingeniously remarks, that a very fusible metal united to one much less so, renders it brittle at such a degree of heat, as by melting the first, destroys the continuity of the parts of the mixture.

When therefore the astringent principle combines with an animal substance, it communicates to it, the properties which it derives
from

from the charcoal; the animal substance becomes less liable to change from slight variations of temperature; instead of growing putrid, it suffers a slight degree of combustion, by the action of the air; for the process of tanning probably could not go on in a perfectly close vessel: the effect of this combustion is the constriction of the parts, which also, afterwards assists as a cause of preservation. The preliminary operations in tanning, consist principally, in extracting all the fatty particles diffused through the cellular texture of the skins, that the astringent principle, and even the air, may have free access every where.

In considering the analyses that have been made of indigo, which may be looked upon as the colouring matter least liable to change, of any we are acquainted with, I find, that this substance leaves in distillation, a greater proportion of charcoal than even galls themselves (Sect. II. Vol. II). I neglect in this estimate, the charcoal which enters into the composition of the thick oil, which is obtained chiefly from indigo, and that which is extricated in the form of carbonic acid, and hydrogenous carbonic gas.

I conceive that it is also to this abundance of charcoal, that the durability of the colour

of indigo is to be attributed, and that the proportion of this principle is the chief cause of the difference observed in the durability of colours; but the force of adhesion may also have great influence, for a principle which combines intimately with another substance, ought to form with it a more permanent compound, than one which has only a slight disposition to unite with it; now the astringent principle possesses a very strong disposition to form intimate combinations, especially with animal substances. I shall explain upon the same principles, the fixity communicated to colouring particles by alumine, and by those metallic oxyds which are not liable to contain different proportions of oxygen, such as oxyd of tin.

All the colouring substances which are capable of uniting with metallic oxyds, have an action upon them, which is analogous to that of astringents.

The oxyds are thus deprived of more or less of their oxygen, according to the force with which they retain it, the strength of attraction with which the colouring particles tend to combine with them, the proportions in which they meet with each other, and the greater or less disposition of the colouring particles towards combustion. The colouring

particles also, suffer a change in their constitution from these circumstances; thus, the solutions of iron render brown, all the colours into which oxyd of iron can enter, although it has only a green or yellow colour, in the state in which it is held in solution by acids, and this effect goes on increasing to a certain degree; but the alteration of the colouring particles may afterwards be pushed so far, as to spoil their colour, and to diminish their tendency to combination; the oxyd of iron is then brought back to the yellow colour, by the oxygen which it attracts, and is capable of retaining. The action of metallic oxyds and the colouring particles on each other, explains the changes observed in solutions of the colouring particles, when mixed with metallic solutions. The effect is gradual, as I have shewn with respect to fustic. Sometimes, the mixture does not even grow turbid immediately, but loses its transparency by degrees; the precipitation begins; the sediment is formed, and its colour grows more and more deep. Light has sometimes a considerable influence in producing these effects.

C H A P. VI.

*Recapitulation of the Theory laid down in
this Section.*

METALLIC colours must be distinguished from those which are peculiar to vegetable and animal substances.

The colours of metals are modified and changed by oxydation, and by the proportion of oxygen combined with them.

Vegetable and animal substances may themselves possess a peculiar colour, which varies in the different states through which they pass, or they may owe their colours to tinging particles, either combined, or simply mixed with them. These are the particles which are extracted from different substances, and which undergo different preparations, to fit them for the purposes of dyeing.

The colouring particles have chemical properties which distinguish them from all other substances: the attractions which they have for acids, alkalis, earths, metallic oxyds, oxygen, wool, silk, cotton, and linen, constitute the chief of these properties.

According to the attraction which the colouring particles have for wool, silk, cotton, and linen, they unite more or less readily, and more or less intimately with each of these substances; and thence arises the first cause of variation in the processes employed, according to the nature of the stuff and of the colouring substance.

By the attraction which the colouring particles have for alumine and metallic oxyds, they form compounds with these substances, in which their colour is more or less modified, becomes more fixed, and more difficultly affected by external agents than before. This compound being formed of principles, which have separately the power of uniting with vegetable substances, and more especially with animal substances, preserves this property, and forms a triple compound with the stuff; and the colour which has been again modified by the formation of this triple union, acquires a greater degree of fixity, and of indestructibility by external agents.

The colouring particles have frequently so great an attraction for alumine and metallic oxyds, that they separate them from acids which held them in solution, and fall down with them; but the attraction of the stuff is

sometimes necessary, in order to produce this separation.

The metallic oxyds which combine with the colouring particles, modify their colours, not only by their own, but also by acting upon their composition by means of their oxygen. The change which the colouring particles thereby suffer, is similar to that occasioned by the air, which injures all colours more or less.

Of the two principles which compose the air of the atmosphere, it is only the vital air or oxygenous gas, which acts upon the colouring particles: it combines with them, weakening their colour, and rendering it paler; but presently, its action is principally exerted on the hydrogen which enters into their composition, and it then forms water. This effect ought to be considered as a true combustion, whereby the charcoal which enters into the composition of the colouring particles, becomes predominant, and the colour commonly changes to yellow, fawn colour, or brown; or the injured part, by uniting with what remains of the original colour, produces other appearances.

Light favours the combustion of the colouring particles, which frequently cannot take place without its aid, and it is thus that it
contributes

contributes to the destruction of colours. Heat promotes it also, but less powerfully than light, provided that it has not a certain degree of intensity.

To a similar combustion are to be attributed the effects of the nitric acid, of the oxygenated muriatic acid, and even of the sulphuric acid, when they make the colour of the substances upon which they act, pass to a yellow, and even to black ^a.

^a There are a great number of other natural phenomena besides those which I have pointed out (*Ann. de Chym.* tom. vi.) in which the formation of water appears to me indisputable: thus the acerb flavour of unripe fruits, is probably owing to the oxygen being weakly combined in them; but by maturation, the fruit from having been hard, grows soft; water is formed; the juice becomes abundant and sweet; now, sugar contains a considerable portion of charcoal. When their maturity advances too far, and the fruits undergo that decay which is peculiar to them, their colour indicates a superabundance of charcoal. It appears by the experiments of the celebrated Mr. Ingenhouze (*Exp. sur les végét.* tom. ii.) that combustion takes place on the surface of fruits exposed to the sun, so strongly, as to produce carbonic acid.

Dung, either by itself or mixed with straw, is changed into mould, by a degree of combustion which is even accompanied with considerable heat, so that the charcoal becomes superabundant in it; hence probably arise many of the phenomena of vegetation.

The effects of combustion however, may be concealed, by the oxygen combining with the colouring particles, without acting particularly on the hydrogen.

Colours are more or less durable, or more or less fixed, according to the greater or less disposition of the colouring particles, to suffer this combustion, and to allow it to go on to a more or less advanced stage.

Some substances are also capable of acting on the colour of stuffs, by a superiority of attraction, or by a solvent power; and in this consists the action of acids, alkalis, and soap, a small quantity of these agents however, may sometimes form supracompounds with the stuff, and thereby change its colour.

Metallic oxyds produce in the colouring particles with which they unite, a degree of combustion, proportioned to the quantity of oxygen, which can be taken from them by these particles.

The colours which the compounds of metallic oxyds and colouring particles assume then, are the product of the colour peculiar to the colouring particles, and of that peculiar to the metallic oxyd; but the colouring particles and metallic oxyds must be considered in that state, to which they have been reduced by the
diminution

diminution of oxygen in the oxyd, and the diminution of hydrogen in the colouring particles.

Hence it follows. First, that the metallic oxyds, to which the oxygen is only slightly attached, are not fit to serve as connecting media for the colouring particles, because they produce in them too great a degree of combustion; such are the oxyds of silver, gold, and mercury.

2. That the oxyds which undergo considerable changes of colour, by giving off more or less of their oxygen, are also bad intermediates, especially for light shades, because they produce changeable colours; such are the oxyds of copper, of lead, and of bismuth.

3. That the oxyds which strongly retain their oxygen, and suffer very little change of colour by the loss of a part of it, are best fitted to answer this purpose; such is particularly the oxyd of tin, which quits its menstruum easily, which has a strong attraction for the colouring particles, and which affords them a basis which is very white, and proper for giving a brightness to their shades, without altering them by the admixture of another colour. The oxyd of zinc possesses some of these qualities.

In

In order to account for the colours, which result from the union of the colouring particles with the basis which a mordant gives them, we must attend to the proportion in which the colouring particles unite to that basis; thus, the solution of tin, which produces a very copious precipitate with a solution of colouring particles, and which thereby proves, that the oxyd of tin enters in a large proportion into the precipitate, has a much greater influence on the colour of the precipitate, by the whiteness of its basis, than the solution of zinc, or that of alum, which generally produce much less copious precipitates. The precipitates produced by these two last substances, retain very nearly the natural tint of the colouring particles.

We must then distinguish in the action of mordants, the combinations that may take place by their means, between the colouring particles, the stuff, and the intermede; the proportions of the colouring substance and intermede, the modifications of colour, which may arise from the mixture of the colour of the colouring particles, and of that of the basis to which they are united, and finally, the changes which the colouring particles may suffer, from
the

the combustion that may be produced by the intermede.

Astringents do not derive their characteristic property from an acid, or from any other individual principle which is always the same, but from the property which they possess, of uniting with the oxyd of iron, of reducing it to the state of black oxyd, and of acquiring themselves a dark colour, by the combustion they thereby experience; galls, which are to be considered as the type of astringents, readily undergo a slight combustion, which gives them a deep brown colour; but this combustion, which requires but a small quantity of oxygen, soon ceases, without injuring their properties.

Galls owe their stability to the large proportion of charcoal they contain; and as they have the property of combining with some vegetable substances, with several colouring matters, and particularly with animal substances, they serve as intermedes for them, and impart to them their own stability.

SECTION

SECTION II.

Of the Processes of Dyeing in General.

C H A P. I.

Of the Differences between Wool, Silk, Cotton, and Linen, and the Operations, by which these Substances are prepared for taking the Dye.

ARTICLE I.

Reflections on the Difference between Vegetable and Animal Substances.

THOUGH we cannot hope to account for many properties which depend upon the composition of organized bodies; yet the knowledge we have acquired respecting the composition of vegetable and animal substances, may afford us some light respecting the cause of the different dispositions of wool, silk, cotton, and linen, to unite with the colouring particles, and with the bases supplied by mordants.

Wool and silk, are animal substances; cotton, flax, and hemp, are vegetable productions.

The

The composition of animal substances is distinguished from that of vegetables, by their abounding in a particular principle *azot*, which, when in its elastic form, constitutes what is called *phlogisticated gas*, *phlogisticated air*, &c. which is found only in small quantity in vegetables; secondly, by their containing much more hydrogen, or base of inflammable air.

From these two causes, arise the differences observed in the distillation of animal and vegetable substances. The former yield a large quantity of ammoniac (volatile alkali) which is composed of azot and hydrogen; the latter afford very little, and commonly yield even an acid; the former yield a great deal of oil, the predominant principle in which, is hydrogen, which is very volatile and disposed to fly off by a small increase of temperature, while the latter sometimes do not yield it in the least sensible quantity. In consequence of this composition, animal substances, when set on fire, produce a bright flame, which breaks out at the beginning, but is soon stifled as it were, by the charcoal which is formed, and which has peculiar properties; their combustion is accompanied with a penetrating odour, owing to the ammoniac and oil which are produced and escape unconsumed: they are liable to putrefaction, in which process
ammoniac

ammoniac is produced, as well as in their distillation, by a more intimate union of the azot and hydrogen; while vegetable substances, on the contrary, undergo the vinous or acetous fermentation. I barely mention these ideas here, which I have explained at length in some memoirs.

As animal substances contain a considerable quantity of principles disposed to assume an elastic form, they have less cohesive force among their particles than vegetables have, and a greater disposition to combine with other substances; hence they are more liable to be destroyed by different agents, and are more disposed to combine with colouring particles.

Thus, pure or caustic fixed alkalis destroy animal substances, because they combine with them, and are saturated by them, losing their causticity (*Mem. de l'Acad.* 1783). The consequence of this action of alkalis on animal substances, is, that they cannot bear leys, and that alkalis should be used with great caution, in the processes employed for dyeing them; whereas, no danger is to be apprehended from the use of alkalis with vegetable substances.

The nitric and sulphuric acids have also considerable action on animal substances; the former decomposes them, extricates the azot, separates

separates the fatty matter, and forms carbonic and oxalic acids with a part of the hydrogen and a part of the charcoal: the latter extricates the inflammable gas, probably azotic gas, and reduces the other principles to the state of charcoal.

Silk appears to bear some resemblance to vegetable substances, by being less disposed to combine with colouring particles, and by resisting the action of alkalis and acids more powerfully; which may arise either from the same principles being more intimately combined in it than in wool, or more probably, from its containing less azot and hydrogen: but though the action of alkalis and acids upon silk is weaker than upon wool, they should still be employed with great caution, because the brightness of colour required in silk, appears to depend upon the smoothness of its surface, which should therefore be preserved unimpaired.

Cotton withstands the action of acids better than flax or hemp, and is difficultly destroyed even by the nitric acid.

ARTICLE II.

Of Wool.

THE principal differences in wool consist in the length and fineness of its filaments. That

which has the finest filaments, is reserved for fine cloths. The most beautiful wool is brought to us from Spain. Mr. d'Aubenton has shewn, that it may be produced in France, of a quality not inferior to that of Spain, by folding the sheep through the whole year, and choosing the rams with care. Simple inspection may easily lead to error respecting the fineness of wool, which it is so important the manufacturer should know with accuracy; he has proposed a method of attaining that accuracy, by employing a micrometer for comparing, by means of a microscope, the fineness of the wool to be examined, with that of other wools chosen as standards^a.

Although the long wool is not so fine as the Spanish, and cannot be employed for fine cloths, it is still very useful for those commonly known by the name of english cloths; and as the sheep which produce it, have much larger fleeces, the profit they bring, is not inferior to that of the fine woolled sheep; besides, the cloths made of their wool, being cheaper, have a much more extensive sale; and the prosperous state of the commerce of England, is partly owing to the abundance of this wool. But the breed of sheep,

^a Mem. de l'acad. 1779. Instructions to shepherds and proprietors of flocks.

which produces one or the other kind of wool, is connected with the nature of their pasture, which ought to determine us in the choice of them.

The multiplication of our flocks and the improvement of our wool, is of so great importance to our industry, that no opportunity should be lost of calling the attention of the public to that object.

Wool is naturally covered with a kind of grease, called *suint*, which preserves it from moths^b, so that it is not scoured until it is about to be dyed, or spun.

In order to scour wool, it is put for about a quarter of an hour into a kettle, containing a sufficient quantity of water, mixed with a fourth of putrid urine, heated to such a degree as the hand can just bear, and it is stirred from time to time with sticks; it is then taken out, and put to drain: it is next carried in a large basket to a stream of running water, where it is moved about until the grease is entirely separated, and no longer renders the water turbid; it is then taken out, and left to drain. It sometimes loses

^b Reaumur has observed, that rubbing a stuff with greasy wool, was sufficient to preserve it from moths. Mem. de l'acad. 1728.

in this operation more than a fifth of its weight. The scouring should be carefully performed, because the wool is thereby better fitted to receive the dye.

The ammoniac, or volatile alkali, formed in putrid urine, unites with the grease, producing a kind of soap, which is soluble in water.

The wool is died in the fleece, or before it is spun, chiefly when it is intended to form cloths of mixed colours ; or else it is dyed after being spun, and it is then intended principally for tapestry : but it is most commonly dyed, after having been wrought into cloth.

When wool is dyed in the fleece, its filaments being separate, absorb a larger quantity of the colouring particles than when it is spun ; for the same reason, woollen yarn takes up more than cloth : but cloths themselves vary considerably in this respect, according to their degree of fineness, or the closeness of their texture ; besides the variety in their dimensions, the different qualities of the ingredients employed in dyeing, and a difference of circumstances in the process, prevent us from relying upon the precise quantities we find recommended for the processes described. This consideration ought to extend to all dyes.

For most colours, wool requires to be prepared by a bath, in which it is boiled with saline substances, principally with alum and tartar; this is called the *bouillon*, which will be accurately described in the different processes: but there are some dyes for which the wool does not require such a preparation; then, it must be well washed in warm water, and wrung out, or left to drain. This is a general rule which should be observed with respect to all the substances we wish to dye, in order that the colour may penetrate them more easily, and be distributed more uniformly.

Mr. Monge has explained the operation of felting (*feûtrage*) and the effects of fulling, by the external conformation of the wool and hair of animals. He has made some curious observations* on this subject, the chief of which I shall now relate.

Nothing particular can be discovered by means of the microscope, in the filaments of wool or in the hairs of animals; yet the surfaces of these bodies are not smooth; they must be formed either of small laminæ placed over each other in a slanting direction from the root towards the point, like the scales of fish, which cover

* Observations sur la mechanisme du feûtrage. Ann. de Chym. tom. vi.

each other, from the head of the animal to the tail; or more probably, perhaps, of zones placed one upon another, as we see in the horns of animals.

If a hair be laid hold of by the root in one hand, and drawn between the fingers of the other, from the root towards the point, scarce any friction or resistance is perceived, and no noise is heard; but if grasping it by the point, it is passed in the same manner between the fingers of the other hand, from the point towards the root, a resistance is felt which did not take place in the former case, and a tremulous motion is perceptible to the touch, and a noise sensible to the ear.

We perceive then, that the texture of the surface of hair is not the same, from the root towards the point, as it is from the point towards the root, and that a hair when pressed, must meet with greater resistance, in sliding or moving towards the point, than towards the root; but as it is this texture itself, which forms the principal subject of Mr. Monge's memoir, it is necessary to confirm it by some further observations.

If, after having laid hold of a hair between the thumb and fore finger, we rub them against each other, in the longitudinal direction of the
hair,

hair, it acquires a progressive motion in that direction towards the root. This effect depends neither on the nature of the skin of the finger, nor on its texture; for if the hair be turned, so that the point shall be placed where the root was before, its motion will now be in an opposite direction, that is, it will still be towards the root.

These observations, to which Mr. Monge adds some others, are related of human hair, taken as an example, but they are equally applicable to the filaments of wool, to horse hair, and to that of animals in general. The surface of all these bodies then, is formed of rigid laminæ, laid upon each other like tiles, from the root to the point, which allow a progressive motion towards the root, but oppose one towards the point.

This structure is the principal cause of the disposition to felting (*feûtrage*) which the hair of animals generally possesses; the latter, by striking the flocculi of wool with the string of his bow (*archet*) detaches and disperses in the air, each of the filaments separately; these fall back one upon another, in all directions, on the table, where they form a layer of a certain thickness; the workman then covers them with a cloth, upon which he presses in all parts, with his hands extended.

The pressure brings the filaments of wool nearer to each other, and multiplies the points of contact; the agitation gives each of them a progressive motion towards its root, by means of which, they entangle each other, and the laminæ of each filament, taking hold of those of the other filaments, which are in an opposite direction, the whole is retained in the state of close contexture, which it had acquired by the pressure

In proportion as the texture becomes closer, the pressure of the hands ought to be increased, both in order to make it still more compact, and to keep up the progressive motion, and intermixture of the filaments, which now meet with greater resistance: but during the whole of this operation, the filaments of wool lay hold of each other only, and not of the cloth, the fibres of which, as has been already observed, are smooth, and have not the same properties in this respect.

The aptitude for felting in wool and hair, does not depend entirely on the structure of their surface; it is not enough, that each filament should have a progressive motion towards its root; nor that the inclined laminæ, by laying hold of each other, should retain the contexture in the state to which it has been reduced
by

by compression: it is also necessary, that the filaments should not be straight like needles; for, by a continuance of the motion and pressure, each of them would continue its course progressively, without changing its direction, and the effect of the operation would be, to remove them all from the centre, without producing any contexture. It is therefore necessary, that each filament should be crooked, so that the extremity nearest the root, should be disposed to change its direction continually, to entwine itself round fresh filaments, and to return back upon itself, if it should be so determined, by any change in the position of the rest of its length.

Wool possessing this structure naturally, is peculiarly fitted for this kind of work, and may be employed in it, without being subjected to any previous preparation; but the furs of rabbits, hares, and beaver, are naturally straight, and cannot be employed alone for felting, without having undergone a previous operation, which is called *secretage*, which consists in rubbing them before they are stripped, with a brush moistened with a solution of mercury in nitric acid; this liquor, by acting only on one side of the hairs, changes their rectilinear direction, and communicates to them that disposition for felting, which wool has naturally.

The

The operation of *fulling* woollen stuffs is so closely connected with felting, that I cannot avoid entering a little into that subject at present.

The asperity of the surface of the filaments of wool, and their disposition to acquire a progressive motion towards the root, forms an obstacle to the spinning of wool, and the working it into stuffs, all the filaments must therefore be covered with a coat of oil, which by filling the cavities, renders the asperities less sensible, just as a coat of oil renders a fine file still smoother. When the piece of stuff is wrought, it must be freed from that oil, which gives it a disagreeable smell, renders it dirty, and would prevent it from taking the colour we wish to dye it; for this purpose, it is taken to the fulling-mill, where it is beaten with large beetles, in a trough of water, through which some clay has been diffused. The clay uniting with the oil, renders it soluble in the water, and both are carried off together, by fresh water brought thither by the machine; and after some time, the stuff is found clean scoured.

But scouring is not the only object in fulling; the alternate pressure of the beetles on the stuff, particularly when the scouring is advanced, produces an effect analogous to that of the pressure of the hatter's hands; the filaments of
wool

wool which compose a thread of the warp or of the woof, acquire a progressive motion, insinuate themselves into the adjoining threads, then into those which are next, and presently, all the threads both of the warp and woof, are felted together. The stuff is now found contracted in length and breadth, and participates both of the nature of cloth and of felt; it may be cut without being subject to ravel, and there is no necessity for hemming the different pieces of it employed to make a garment. If it be common woollen stocking web, the stitches are now no longer subject to run, when one of them happens to slip; finally, the threads of the warp and the woof, being now no longer so well defined, nor so distinct from each other, and the stuff being also thickened, forms a warmer clothing.

ARTICLE III.

Of Silk.

SILK is naturally coated with a substance, which has been considered as a gum, to which it owes its stiffness and elasticity; that which is most commonly met with in our climate, contains besides, a yellow colouring matter.

Most

Most of the purposes for which silk is employed, require that it should be deprived not only of its colouring matter, but also of its gum. Both these purposes are answered by means of soap, and the term scouring (*décreusage*) is applied to this operation, by which it acquires its suppleness and whiteness. The scouring ought not to be so complete for silks which are to be dyed, as for those which are intended to remain white, and a difference ought even to be made, according to the colour we mean the silk should have.

This difference consists chiefly in the quantity of soap employed; thus, for common colours, it is generally thought sufficient, to boil the silk for three or four hours, in a solution of twenty pounds of soap for each hundred of silk, taking care to fill up the kettle with water from time to time, that there may be always a sufficient proportion of fluid. The quantity of soap is increased for those silks which are to be dyed blue, and more especially for those that are to be scarlet, cherry-colour, &c. because, for these colours the ground must be whiter, than for such as are less delicate. In treating of each colour, the quantity of soap proper for the silk intended to receive it, is mentioned.

When

When filk is to be employed white, it undergoes three operations, the first is called *dégommage*; it consists in keeping the hanks of filk in a solution of thirty pounds of soap to a hundred of filk: this solution ought to be very hot, but not boiling; when that part of the hanks which is immerfed is entirely freed from its gum, which is known by the whiteness it acquires, the hanks are turned upon the skein sticks, so that the part which was not before immerfed, may undergo the same operation*; they are then taken out of the kettle, and wrung out, according as the operation is completed.

The second operation, is the *cuite*. The filk is put into bags of coarse cloth, five and twenty or thirty pounds in each bag, which is called a boiling bag (*poche*); a bath of soap is prepared like the former, but with a less quantity of soap; in this the bags are boiled for an hour and a half, taking care to keep them constantly stirred, that those which touch the bottom of the kettle, may not receive too much heat.

The third operation is called *blanchiment*, which is principally intended to give the filk a slight cast, to make the white more pleasing, and from which it derives different

* This is called by our workmen, *shaking over*.

names, such as china white, silver white, azure white, or thread white. A solution of soap is prepared, the proper strength for which is determined, by its mode of frothing when agitated; for the china white, which should have a slight tinge of red, a small quantity of anotta is added, and the silk is shaken over in it, until it has acquired the desired shade. To the other whites, more or less of a blue tinge is given, by adding a little blue to the solution of soap; though some had before been put into the *cuite*.

To prepare the azure, fine indigo is taken, and after being well washed two or three times in moderately warm water, it is ground fine in a mortar, and boiling water poured on it; it is then left to settle, and the liquor alone is employed, which retains only the most subtile parts; this is called azure. A small quantity of the liquor of a fresh vat of indigo, may be substituted for azure.

At Lyons, where they make a more beautiful white than at Paris, no soap is used in the third operation; but after the second, the silks are washed, fumigated with sulphur, and azured with river water. In this method, it is of importance to employ very clear water.

When the silk has become very uniform,

and has acquired the desired shade, it is wrung out and dried.

The white obtained by these means is not yet sufficiently bright, for the silk intended for white stuffs; but must still be exposed to the vapour of sulphur: this operation is described under the article sulphur.

As soap seems to impair the lustre of silk, the academy of Lyons, in 1761, proposed as the subject of a prize dissertation, to find a method of scouring silks without soap; and the prize was adjudged to Mr. Rigaut, of St. Quentin, who proposed substituting for soap, a solution of soda, or carbonat of soda, so much diluted with water as not to injure the silk; but some inconvenience must have attended the practice of this method, as it is not adopted, though generally known and easy of execution.

The Abbé Collomb^d has published some observations highly worthy of attention, respecting the scouring of silk by the action of water alone. Having perceived that a skein of yellow silk, which he had boiled for about three hours in common water, had lost nearly one eighth of its weight, he repeated the boiling twice, and

^d Observations sur la dissolution du vernis de la soie. Journ. de Phys. Août, 1785.

thereby

thereby brought the diminution to nearly one quarter.

The silk which has suffered this loss of weight, still retains a yellow or rather chamois colour, which renders it unfit for white stuffs, or for such as are intended to receive any colour, the beauty of which depends on the whiteness of the ground, upon which it is applied; but it takes those colours very well which cannot be injured by the tinge it retains; thus the black which it took, seemed preferable to that of silk scoured with soap.

The silk remains very firm and strong after this operation, the threads of it, compared with similar ones scoured with soap, supported weights which broke the others.

Eight hours of brisk ebullition are required, to dissolve the whole gummy coat of silk, and it thereby loses a little more than one fourth of its weight; but the boiling ought to be continued longer, when the barometer is low, because the greater the weight of the atmosphere, the higher is the degree of heat at which water boils.

This consideration led Mr. Collomb to try the effect of boiling silk in Papin's digester, and he found that only one hour and a quarter
were

were required, to complete the solution of the gummy coat, although the degree of heat must have been inferior to that, which produced many of those effects observed by philosophers, in that concentrated kind of ebullition.

I have seen a pattern of silk stuff scoured by Mr. Collomb; it seemed to have the qualities which he mentions; but it had less suppleness and softness than silk scoured with soap.

Mr. le Camus, a learned naturalist of the academy of Lyons, gave me a small quantity of the substance separated from silk by the water, in one of Mr. Collomb's operations; it was black, brittle, and of a shining fracture, and afforded by distillation the usual products of animal substances; it dissolved easily in warm water, and left very little residuum on the filtre; the solution which is transparent and of a greenish yellow colour, was not sensibly affected by acids or alkalis.

Solution of alum produced in it, a dirty white precipitate; that of copper, a dark brown precipitate; that of sulphat of iron, a brown precipitate; nitro muriatic solution of tin (solution of tin in aqua regia) a white precipitate; acetite of lead, a brown precipitate. All these precipitates are in small quantity, and more or

less viscous. The infusion of galls and that of sumach, produce a white precipitate.

Alcohol does not dissolve this substance even by ebullition, taking up only a yellow colouring matter; this solution by evaporation, afforded a residuum of scales of an amber yellow.

I added some drops of muriatic acid to nearly two ounces of alcohol, and boiled it on twenty grains of the silk gum, a solution took place, but on cooling, this substance put on the appearance of jelly.

The substance taken from the silk in the scouring then, appears to be of an animal nature, and therefore, the soap suds used in that operation soon become putrid; when separated from the silk, it is easily dissolved in water, but not in alcohol. Though not of a vegetable nature, it may with considerable propriety be called a gum. That part which gives it the yellow colour is soluble in alcohol, and when it is separated, the gum becomes brown. It is not improbable that this colour is occasioned by the heat to which it is exposed in the boiling, because, when only the yellow colouring part is separated by Mr. Beaume's process, which I shall presently describe, the silk is whitened.

In Mr. Collomb's process, the gum is separated, and takes with it only some of the colouring particles; and in the process of scouring by soap, the gum and the yellow colouring particles are carried off together.

I boiled some yellow silk in a retort, where as the vapours did not escape so freely as from an open vessel, a degree of heat must have been produced, superior to that of water boiling in the open air. After having been boiled for four hours, the silk had lost one fourth of its weight, but it had almost entirely retained its colour.

I boiled another pattern in the same way, in a quantity of water impregnated with common salt, it became whiter, but lost less of its weight, though the degree of heat was certainly increased by the addition of the salt, which restrained the evaporation of the water; possibly, a part of the salt had united with the silk. Experiments might be made with other salts, and perhaps we should find some, that, without injuring the silk, might be more useful in dissolving the gum and colouring particles.

When silk is intended for the manufacture of blonds and gauzes, its natural elasticity and stiffness should be preserved; the greatest part

of what is produced in these climates, is of a yellow colour, but it is the white china silk that is principally used for these purposes; this is so dear, that our manufacturers cannot vie with the English, from whom we get it, as they always reserve the finest for their own manufactures; it has therefore been a desideratum, to find out the means of depriving the yellow silk of its colouring particles, without destroying the gum, and thereby depriving the silk of its elasticity. Mr. Beaumé has solved this interesting problem, but has kept his process secret: some artists however, to whom he intrusted it, or who had been led to the discovery by their own observations, succeeded in the execution of it; but the process appears to be liable to accidents, which by occasioning loss, increase expence, so that hitherto, notwithstanding the advantages it presents, it has not been carried into execution. I shall communicate what has transpired respecting it.

A mixture is made with a small quantity of marine acid and alcohol, in which the silk is immersed; the marine acid must be pure, and not contain any nitric acid, which makes the silk yellow. To give it an uniform white colour seems to be one of the most difficult parts

parts of the process, especially when we operate on large quantities. There is likewise great difficulty in dyeing the whitened silk, so as to prevent its curling, it ought certainly to be kept constantly stretched during the drying. The alcohol that has been impregnated with the colouring part, must be again separated from it, so as to serve for subsequent operations, otherwise the process would be too expensive; for this purpose it is to be distilled by a gentle heat, in a glass or stone ware vessel.

It appears from the experiments above related, that the marine acid is useful in this process, by softening the gum, and thus assisting the alcohol to dissolve the colouring particles combined with it.

The preparation with alum must be considered as one of the general operations in dyeing silk, for without aluming, the greatest part of the colours applied, would possess neither beauty nor durability.

The preparation with alum consists in mixing in a tun or vat, about forty or fifty pails of water with forty or fifty pounds of roman alum, that has been previously dissolved in warm water; this must be carefully stirred during the mixture, to prevent the crystallization of the alum.

After having washed and beetled the silk, and wrung it out with the jack and pin^c, in order to separate any soap it may have retained, it is immersed in the alum liquor, where it is left for eight or nine hours, after which, it is wrung out by hand, over the vat, and washed in a stream of water.

In the above quantity of liquor, one hundred and fifty pounds of silk may be prepared, without the addition of any more alum, but when it begins to grow weak, which those who are in the habit of employing it, can easily distinguish by the taste, twenty or twenty-five pounds of dissolved alum must be added as before, and this addition must be repeated, until the liquor acquires a disagreeable smell; and then, it may be employed in the preparation of stuffs intended for darker colours, such as browns and marones, till it has lost all its strength.

The preparation of silk with alum is always made in the cold, because when the liquor is

^c This is a contrivance for wringing more strongly, than can be done by the hands alone; the pin introduced through the hank at one end, or into a twist of the cloth, is secured in a fixed position, while the other end or twist is fixed to the hook of the jack, which can be forcibly turned round by means of a winch connected with it. When this degree of force is not necessary, and the hands only are employed in the operation, it is called *wringing out by hand*. T.

employed

employed hot, the lustre of the silk is liable to be impaired.

ARTICLE IV.

To describe the *Off Cotton*.

COTTON is the down or wool contained in the pods of a tree or shrub^f which grows in warm climates. This down is separated from the seeds, which it covers, by a kind of mill.

Climate has great influence on the qualities of cotton; and the species of the cotton tree seem to differ according to the heat of the country in which they grow^g; great variety of them are found in the american islands; but it appears from Mr. Bennet's account^h, that the

^f Of the four species of the cotton plant (*Gossypium*) only one is perennial, and therefore called the *arborescens* which grows to six or eight feet high. That from which our cotton is commonly got is the *herbaceum*, Lin. which grows only to about two feet in height. The third is the *hirsutum* or hairy american cotton, two or three feet high. The fourth is the *Barbadense* or Barbadoes shrubby cotton, which rises to four feet. These three are all annual plants. T.

^g *Essai sur les caracteres qui distinguent les cotons des diverses parties du monde, &c. par M. Quatremere Disjonval.*

^h *Transactions of the society instituted at London for the encouragement of arts, manufactures, and commerce, vol. I.*

inhabitants have hitherto neglected to choose those species, which would be found most advantageous, and have thus lost much of the benefit, that might be derived from this valuable article.

Cottons differ principally in the length of the filaments, their fineness, their strength and colour.

Cotton is of different shades from a deep yellow to a white; the darkest coloured comes from Siam and Bengal, and is often made into stuffs without changing its natural colour. The most beautiful is not always the whitest, it is necessary to bleach it, by processes similar to those employed in the bleaching of linen. The operations necessary however in bleaching cotton, are less various, and more expeditious, than those for bleaching linen. Instead of these operations, we may employ oxygenated marine acid, and with the assistance of time[†] we can thus produce a more beautiful white, than by the ordinary way of bleaching, and the cotton afterwards appears better fitted for the reception of a fine colour in dyeing, as Mr. Decroisille has observed. I have succeeded in bleaching the yellow cotton of St. Domingo, which has been prohibited on ac-

[†] Annal. de Chymie. tom. ii.

count of its bad colour, which it so obstinately retains.

In order to dispose cotton to receive the dye, it must undergo an operation called scouring. Some boil it in four water*, but more frequently alkaline ley is used, the cotton must be boiled in it for two hours, and then wrung out, after which it must be rinsed in a stream of water, till the water comes off clear, and then dried.

The cotton stuffs which are to be prepared, must be soaked for some time in water, mixed with at most one fiftieth of sulphuric acid, after which they must be carefully washed in a stream of water and dried. I have observed that the acid which had been used in this operation, had taken up a quantity of calcareous earth and iron, which would have injured the colours.

We may consider aluming and galling as operations generally employed in the dyeing of cotton and linen.

In the preparation with alum, about four ounces of it are required to each pound of stuff, it must be dissolved with the precautions mentioned in the preceding article, and some add a solution of soda in the proportion of one sixteenth of the alum, others a small quantity of tartar and arsenic. The thread is well

* Vid. chap. xii. sect. iii. vol. i. T.

impreg-

impregnated by working it pound by pound in this solution, it is then put altogether into a vessel, and what remains of the liquor is poured upon it; this is left for twenty-four hours, and then removed to a stream of water, where it is suffered to remain for an hour and an half or two hours, in order to extract a part of the alum, and it is then washed. I have found that cotton gains about one fortieth of its weight in this operation.

In the operation of galling, different quantities of galls or other astringents are employed, according to the quality of the astringents, or the effect desired.

The galls powdered, are boiled for about two hours, in a quantity of water proportioned to that of the thread to be galled; the liquor is then suffered to cool to a temperature which the hand can support, after which it is divided into a number of equal parts, that the thread may be wrought pound by pound, and what remains after the operation, is poured upon the whole together, as before described in the process of aluming. It is then left for twenty-four hours, especially when intended for madder for black, but for other colours twelve or fifteen hours are sufficient. After this it is to be wrung out and dried.

When

When stuffs are galled which have already received a colour, the operation must be performed in the cold, that the colour may not be injured.

I have found that cotton which has been alumed, acquired more weight in the galling, than that which had not undergone that process; although alum adheres but in small quantity to cotton, it communicates to it a greater power of combining, both with the astringent principle and with the colouring particles.

ARTICLE V.

Of Flax.

AS flax and hemp possess the same properties so far as relates to dyeing, we have generally made no distinction between them in this work.

If cotton be an important object for the exercise of our industry, flax and hemp are of still greater consequence, both as they are the product of our own country, and as they afford a source of very extensive employment to the lower orders of the community. The manufacture is extended to all parts of the country, and is divided into various branches, from that
of

of the strongest cordage, to the finest kind of thread ; it is a means of collecting together the families of the peasants in the intervals of more laborious employment, and thus gives them some share in the enjoyments of society ; it affords an easy occupation for infancy and age, which may inure the former to habits of industry, and afford a relief to the latter.

As we are at present paying so much attention to the draining of marshes, and as the number of small tenures is likely to be increased, it is of some consequence to observe, that marshy grounds which have been drained, are the best calculated for the culture of hemp, and that this is a kind of produce that would be found particularly convenient to the inferior farmers ^k.

Flax must undergo several preparations before it is in a proper state to receive the dye ; the first is the watering, by which the fibrous parts of the plant become disposed to separate, so as to be rendered fit for spinning. The watering is an operation of so much consequence, from its influence on the quality and quantity of the product, and from its deleterious effects

^k Instruction familiere sur la culture & le roui du chanvre, a l'usage des gens de la campagne, par M. de Pertuis.

on the air, that it appears proper that I should give some information respecting the place in which it ought to be conducted.

In the watering, a glutinous juice which holds the green colouring part of the plant in solution, and which is the medium of union between its cortical and ligneous parts, undergoes a greater or less degree of putrefaction, according to the mode of conducting the operation; this appears from the extrication of carbonic acid and inflammable gas, which Mr. Rosier¹ has observed to take place.

This substance appears greatly to resemble the glutinous part, that is held dissolved in the juice we get from green plants by pressure, which is separated along with the colouring particles by a heat approaching to that of ebullition, which becomes putrid, and which affords ammoniac by distillation: but though this substance is held in solution in the expressed juice of plants, it is probable however, that water alone cannot sufficiently separate it from the cortical parts; whence it happens, that the hemp which has been watered in too strong a current, is deficient in suppleness and softness.

¹ Essai sur la culture & le rouissage du chanvre; par M. l'abbé Rosier.

If, on the contrary, the water employed in this operation be stagnant and putrid, the hemp acquires a brown colour; but more especially loses its firmness, and exhales very pernicious vapours.

It appears then that this process is performed to the greatest advantage, in watering pits situated on the banks of rivers, where the water may be changed often enough to prevent a putrefaction, that would injure the hemp, and be prejudicial to the workmen; yet not so often, as to hinder the degree of putrefaction necessary for rendering the glutinous substance soluble in water.

Mr. Rosier has found that the operation went on when the hemp was covered with a layer of earth, and he recommends that method. Mr. Prozet^m has proposed the mixing a small quantity of caustic alkali with the water, with a view of increasing its solvent power, and preventing putrefaction; but it appears from Dr. Home's experiments, that the alkali retards the operation, and renders the flax liable to breakⁿ.

During the watering of the flax, and the degree of drying it may have undergone both

^m Mem. sur le rouissage du chanvre.

ⁿ Essay on the bleaching of linen, pag. 370.

before and after, its green colouring particles suffer a change, similar to what we observe in the green substance of plants exposed to the action of air, and the influence of light.

Their colour changes to a yellow, fawn colour, and even becomes brown, from that combustion, the theory of which I have given in the first section. A great part is then soluble in alkalis without requiring a higher degree of oxygenation, so that, by treating the dressed flax with an alkaline solution, we can deprive it of a considerable portion of the colouring matter, which perhaps remains combined with a part of the gluten. The processes published by the prince of S. Séver for obtaining fine dressed hemp, depends on a solution of these colouring particles°. He directs us to lixivate the dressed hemp in a solution of two parts of soda, and one of lime, then to impregnate it with soap and keep it in digestion, to wash it well and afterwards to hackle it.

I have endeavoured to whiten dressed hemp completely, by the method I employed for thread, but though we should expect that its filaments would by this means lose but little of their firmness, yet they become so much disposed to split, and separate from each other,

• Journ. de Phys. introd. tom. ii.

that they would prove much more difficult to twist, and would give a much weaker thread. I have made experiments on dressed hemp prepared in the prince de S. Séver's method, and on some prepared in the ordinary way, with a view of comparing the processes ; the first afforded a greater proportion of tow, and the thread produced from it, was not better in appearance than that of the second, after it had been leyed ; the first was also less firm, but it possessed one advantage which merits attention, that in the hackling, it did not produce that dust which is so pernicious to the workmen.

The beauty which may be communicated to dressed hemp by leying before it is wrought, does not appear to possess the advantages, which its appearance might lead us to expect, since by this means, we dissolve only that portion of the colouring matter, which would have been carried off by the first leys used in the beginning of the bleaching of the cloth. The great fineness given it, probably cannot be produced, but at the expence of the length and firmness of the filaments.

A clergyman of the department of Somme, has rendered his ministry respectable, by directing his attention to an object with which
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the public happiness is very nearly connected. Mr. Brâle has established near Amiens, a kind of public school, in which he examines the methods employed in the culture of hemp, both with respect to the watering, and the dressing with a view of selecting the best, and rendering them as complete as possible ^p.

He employs a process, which probably is not liable to the inconveniences occasioned by laying the dressed hemp; he waters the hemp as soon as pulled, and he separates the cortical part by a peculiar kind of operation immediately after the watering, and having soaked it in a weak solution of black soap, he washes it with great care; previous to the drying, the colouring particles which would have afterwards been soluble only in alkalis, may be dissolved and extracted by water, with the addition of a small quantity of soap, the hemp becomes much whiter and divides better and more minutely without however being injured; and the leys preparatory to the bleaching become unnecessary.

Common thread and the linen made of it, contain then a colouring substance which may

^p Analyse pratique sur la culture & la manipulation du chanvre.

be extracted by simple leys, but there is likewise a part of this substance, which is really combined with the vegetable fibres, and which cannot be taken away except by the destruction of its nature, by the combustion it undergoes during its combination with oxygen, as I have explained in the first section, Chap. III. thread loses by the operations employed in bleaching, from $\frac{1}{4}$ to $\frac{1}{3}$ of its weight.

Flax intended to be dyed, must be subjected to the operations which cotton undergoes, in the scouring, aluming, and galling.

C H A P. II.

Of Dye-Houses, and the Operations employed in the Art of Dyeing.

WHEN we consider it as a general principle, that works carried on in a great manufactory are more advantageous, than those conducted in a detached manner, the subdivision of employment affording an opportunity for each workman, by being engaged by one object, of acquiring celerity and perfection of

of execution, the whole being ordered with one general view, and carried on in all its parts without loss of time; this principle must be considered as peculiarly applicable to the art of dyeing, because what remains after one operation may often serve for another. A bath which has been too much weakened for a particular colour, or even for the lighter shades of that colour (*suites*) may be found serviceable, by affording a ground for other stuffs, or forming a new bath by the addition of fresh ingredients. The galls that have been employed in the galling of silk, may be useful in other operations, on wool or cotton; a great number of instances of the same kind might be enumerated.

It would be easy by considerations of this kind to prove, that the progress of the art of dyeing is very much impeded, by its division into two branches, one comprehending the good or durable dyes, the other, the false or fading colours, by the classification of dyers as they work in silk, wool, or thread, and by the regulations which forbid one class to keep the ingredients destined for the use of the other. We ought, I think, on the contrary, to encourage extensive works in dyeing; and those who direct them, ought to lay down a

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plan

plan of operations which might connect the whole, and prevent all loss of ingredients, of time, of fuel, and of work ; and this plan ought to be regulated by the supposed demands of trade.

A dye-house should be spacious, well lighted, and as near as possible to a stream of water ; it ought to be floored with lime and plaster (*ciment*) and channels should be made for carrying off water, or spent baths ; and the whole should be contrived with the strictest attention to cleanliness.

The caldrons, the size and position of which are to be regulated by the operations for which they are designed, should be made of brass or copper, unless for scarlet, in the preparation of which, it is better to use tin vessels, as well as for other delicate colours in which a solution of tin is employed. Brass is less liable to be acted upon by saline substances, and to spot the stuffs than copper. It is of great consequence that the caldrons or coppers be well cleaned after each operation ; and those of a large size, ought to have at the bottom a pipe with a cock, for the purpose of emptying them. Above each copper, a hole should be made in the chimney, or in the wall, for the reception of poles, for draining the skeins of wool or silk, as well as stuffs, so that the liquor may fall back again into the copper.

For

For the pieces of stuff, a winch or reel is used, the ends of which are placed on two iron forks, which may be put at pleasure into the holes made in the curb which supports the edges of the coppers.

Many dyes for silk, where a boiling heat is not required, are prepared in long copper or wooden vessels, called troughs or backs.

As the greatest parts of the colours used for silk are very delicate, they require to be quickly dried, that they may not change. For this purpose, a drying room is necessary, consisting of a chamber heated by means of a stove; the silk is stretched on a moveable pole, called a shaker, which is hung up, and kept continually in motion, in order to hasten the drying.

It would be necessary to enter into a very minute detail, if I undertook to describe every thing necessary in the construction of a dye-house; more accurate ideas may be at once gained by inspection, than the most laboured description could convey; besides, the disposition of a dye-house, must bear a relation to the operations for which it is intended, and should be so constructed, that those operations may best succeed.

But it is to be wished, both for the progress

of the art, and even of science, that a little place should be reserved for keeping an apparatus for the common experiments in chemistry, as well as for particular experiments relative to dyeing.

The manipulations in dyeing, are neither difficult nor complicated, their object is, to impregnate the stuff to be dyed with the colouring particles dissolved in the bath; to cause the action of the air to concur, both in fixing the colouring particles, and in giving them brightness, and carefully to remove such as have not been fixed in the stuff.

I shall content myself with giving a description of the most common.

When whole pieces of stuff, and even many of these, are to be dyed at once, the winch above described must be used. One end of the stuff being first laid across it, by turning it round pretty quickly, the whole passes over it in succession. It is then to be turned the contrary way; so that the part of the stuff first immersed, may be the last in the second immersion, and thus the dyeing be as equal as possible. If the piece of stuff be of considerable length, or if several pieces are to be dyed of the same colour, the two ends are joined together, the winch then passed within, and put on the forks.

If wool is to be dyed in the fleece, a kind of broad ladder, with the rounds very close^a, is to be placed over the copper, on which the wool is to be put, in order to be drained and aired, or when the bath is to be changed.

If the wool is in skeins, rods are to be passed through them, and the operation is the same as for silk or thread, it consists in turning the hanks of silk, and the skeins of thread or wool, upon the skein sticks in the liquor; this is called shaking over (*liser*) and the rod is called (*lisoir*) skein stick.

When the silk or thread is dyed, it must be wrung out, in order to separate the superabundant colouring particles. This operation is performed with a cylindrical piece of wood, one end of which is fixed in the wall or in a post, and is called (*l'espart*); when this operation is repeated several times successively, for the purpose of drying and giving lustre, it is called (*cheviller*)^b.

When a certain quantity of ingredients are added to a liquor, they say they give it a (*brevet*) and that they rake it, when they stir it about, and mix it with the rake.

Sometimes they give a first colour with an

^a Called by our dyers a scraw or scray. T.

^b See a description of the method employed by our dyers, page 144. T.

intention of applying another upon it ; and thus making a compound colour, and then they are said to give a ground (*donner un pied*).

To rinse, is to wash a silk from the dye, or from the ley, in a small quantity of water, and this they call rinsing (*disbrodure*).

When they are under the necessity of passing a stuff several times through the same liquor, each particular operation is called a dip (*passer*).

A colour is said to be rosed (*rosé*) when the yellow tinge of a red colour is changed to a shade inclining to a crimson or ruby colour, and when they change a yellow red to a more complete red, they are said (*virer une couleur*).

Although the manipulations of dyeing are not very various, and appear extremely simple, they require very particular attention and an experienced eye ; in order to judge of the qualities of the bath, to produce and sustain the degree of heat suited to each operation, to avoid all circumstances that might occasion inequalities of colour, to judge accurately, whether the shade of what comes out of the bath suits the pattern, and to establish the proper gradation in a series of shades.

I do not mean to speak of the management of the vats, nor, above all, of the composition of colours, in which the art principally consists,
and

and where nice combinations are frequently required.

C H A P. III.

Of Fuel.

AS fuel is a principal article of expence in dyeing, it is of great importance to diminish the consumption of it as much as possible, and to select that which may produce the desired effect, with the least possible expence; it is proper therefore to diffuse the knowledge of the philosophical principles of the production of heat by combustion, and of the powers which influence its communication, in order that they may be applied as circumstances require.

When bodies are burnt, none of their principles are destroyed; they had previously formed together one kind of compound, and they now separate from each other, at the high temperature to which they are exposed, in order to form others with the vital air in contact with them: such of the principles as cannot unite with the vital air, that is the earth, some saline
and

and some metallic particles compose the cinder.

The new compounds formed, are carbonic acid, or fixed air, and water: the proportion of these varies according to the proportion of the carbonic particles, and of the hydrogen or basis of inflammable gas, that had been contained in the inflammable body. Let us take common charcoal as an example.

If we burn a hundred grains of charcoal in a glass bell inverted over mercury, after the combustion, we find a quantity of carbonic acid, equal in weight to that of the coal consumed, and of the vital air changed. One hundred parts of this newly formed acid contain sixty-two of oxygen, or base of vital air, and twenty-eight of charcoal (*charbon*); a small quantity of water is also formed, which is dissolved in the carbonic acid, and the vital air likewise holds a little of it in solution. As these quantities are not known, the above estimate cannot be considered as perfectly accurate.

If we burn alcohol or spirit of wine, we have a result considerably different; we obtain a quantity of water greater in weight than the spirit of wine, because the inflammable principle of the alcohol is chiefly hydrogen: now hydrogen forms water, by combining with oxygen,
or

or the basis of vital air; for the same reason also, oil affords a great quantity of water. We may consider charcoal and alcohol, or rather ether, as the two extremes; the former affording by combustion, scarce any thing but carbonic acid, and the latter water; and other combustibles we may consider as intermediate, approaching one or other of these extremes, in a greater or less degree, according to their composition.

While the hydrogen and carbon combine with the vital air, which forms about one-fourth of the atmosphere, the caloric, or principle of heat, which was united with the vital air, and which gave it its elastic form, is in a great measure disengaged; perhaps, there is also extricated from it a portion of carbon, and above all of hydrogen, which was contained in the combustible body; such is the origin of the heat produced in combustion^a.

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^a Although the theory of heat has been considerably improved lately, and has been the subject of many ingenious disquisitions, we shall always, perhaps, be obliged to consider the principles received respecting its nature and combinations, as suppositions only, by means of which we may be able to connect the phenomena it presents, and explain the laws by which it is governed.

When we consider vital air as the source of the heat disengaged

Those who wish to be more particularly acquainted with the experiments of which we have

gaged in combustion, we do not mean to say, that the burning body does not itself contribute to the production of that heat, though by fixing our attention on the principal cause of the phenomenon, we are sometimes apt to content ourselves with mentioning it alone. The whole theory (which has met with some opposition) contradicts such a supposition: but if we observe, that in combustion accompanied with flame, the vital air loses its elastic state in a greater or less degree, while the burning body, so far from being diminished in bulk, enters into a combination which increases it; and if we consider, that the heat disengaged, is proportioned to the quantity of vital air combined, and that in those cases, where little heat is produced by the combination of oxygen, a great deal may afterwards be extricated from the compound, as we see in the case of nitre, and oxygenated muriat of pot-ash; we must acknowledge, that this theory is at least probable and satisfactory.

Among the bodies which most powerfully contribute to the production of heat, hydrogenous gas ought certainly to hold the first rank; now the theory which ascribes to vital air principally, the heat disengaged in combustion, affords in like manner an explanation of the heat produced by this gas; though some, by a false application of Dr. Crawford's experiments, have thence deduced an objection, which they have proposed with a degree of insolent disdain.

I shall not here examine whether Dr. Crawford's hypothesis ought to be admitted or not. He endeavours * to prove, that the heat disengaged in combustion, ought to be attributed to a change of capacity for heat in the burning

* On animal heat, &c.

have just given a slight sketch, and with the theory of combustion at large, should consult several memoirs of Mr. Lavoisier, in the transactions of the academy of sciences, and his

bodies, as appears by comparing the capacity of the body before it is burnt, with the capacity of its residuum after combustion. Dr. Crawford has found, it is said, that hydrogenous gas contains five times as much specific heat as vital air; it ought therefore to contribute much more to combustion than vital air; the heat therefore disengaged in combustion, proceeds principally from the burning body, and not from the vital air.

According to Dr. Crawford, there are two ways of ascertaining the specific heat of bodies, by comparing the subjects of experiment, by bulk or by weight. Dr. Crawford has adopted the latter, which perhaps is more fallacious and more inconvenient than the former. It is in this way then, that we must compare the weights of the oxygenous and hydrogenous gases, which combine in combustion, in order to determine the quantity of heat disengaged from each in proportion to their specific heat. We must therefore take eighty-five parts of oxygen to fifteen of hydrogen. The quantity of heat then disengaged from vital air or oxygenous gas, ought to be to that produced by hydrogenous gas, as eighty-five to seventy-five, or as seventeen to fifteen.

But what still increases the proportion of the heat produced by vital air, according to Dr. Crawford, is, that the specific heat of hydrogenous gas is not five times greater than that of vital air, but only, as 21,4000 to 47,490, and that not so much as fifteen parts of hydrogen are required to eighty-five of vital air.

elements of chemistry, for to him we are principally indebted for this beautiful theory ^b.

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^b In justice to my friend Dr. Crawford, I think it my duty to give the reader a short account of the discoveries respecting heat, to which the author alludes, and to supply a few dates, the accuracy of which I can answer for from my own knowledge: with these dates, it is not surprising that the ingenious author should have been unacquainted, as notwithstanding the high character of Dr. Crawford's work, it has not yet been translated into French, and some of them indeed are not contained in the work itself.

The first in the order of these discoveries, are those of Dr. Black, made in the year 1759, by which it was proved, that ice during its conversion into water, and water during its conversion into vapour, absorbed a large quantity of heat, or elementary fire; hence it was concluded, that other bodies, when they became fluid, and in their conversion into vapour, absorbed heat. These discoveries and inferences form what is called the doctrine of latent heat. The same philosopher proved by experiments on metals, that bodies of different kinds have different capacities for containing heat. Dr. Irvine discovered by a series of experiments made prior to the year 1777, that, when bodies give off heat, in consequence of a change of form, their capacities for heat are diminished, and that the reverse of this takes place, when they absorb heat.

In the spring of the year 1777, Dr. Crawford instituted a series of experiments, with a view to discover the cause of animal heat. In the course of his inquiry, he found, that blood contains a much greater quantity of fire, or of absolute heat, than the elementary substances of which it is composed: hence he inferred, that this fluid must necessarily attract heat from the air, in the process of respiration:

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In order to obtain the greatest possible effect from any combustible body, it is necessary that all

the pure air of the atmosphere must therefore contain more heat, than the fixt air into which it is converted during that process; and as it was well known, that the change produced in the air by the inflammation of combustible bodies, was in a variety of respects, similar to that which it underwent in respiration, he supposed, that the evolution of heat from pure air, was the cause, not only of animal heat, but likewise of that of combustion. This supposition was afterwards confirmed, in the summer of the same year, by experiments made to determine the comparative heats of sulphur and oil of vitriol, of metals and their calces.

Hence it appears, that so early as the summer of the year 1777, the theory of animal heat and of combustion, which is now generally received over Europe, was established by Dr. Crawford, as an inference derived from fact and experiment.

This discovery he communicated to his friends at the university of Glasgow, where he then resided. In the autumn of the year 1777, it was publickly known at Edinburgh; and in the course of the winter, it was explained to a numerous assembly of the students in the royal medical society.

We are told indeed, that Mr. Lavoisier proposed as a conjecture, a theory nearly similar to Dr. Crawford's, in a paper which is said to have been read before the academy of sciences at Paris in the year 1777; but we do not find any account of this theory in the transactions of the academy, till the year 1780. Admitting, however, that Mr. Lavoisier's conjecture was coeval with Dr. Crawford's experiments, it cannot be affirmed with propriety, that he
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all the parts of it, which are capable of combining with vital air, should unite with it; it is consequently necessary, that there should be neither smoke nor soot, this is principally to be accomplished by properly proportioning the inferior opening of the furnace, the fire place, and the chimney.

The current of air which supports the combustion ought to have easy access, but if the chimney be too large, the carbonic acid formed is not removed without some difficulty, it remains in contact with the fuel, and thus opposes its combustion. If the chimney be not sufficiently high, a part of the hydrogen reduced to the form of vapour escapes without being burnt; as do also the coaly particles which form the soot, hence arises a diminution of the effect which the inflammable body ought to have produced. A higher column of air rarified and rendered lighter by heat, and the condensation of the vapours of water and carbonic acid at the top of the chimney, would have concurred in producing a more rapid current of air. These effects are more particularly observable in reverberatory furnaces, in which we easily see the importance of having the opening of the chimney properly proportioned is the discoverer of what he is only said to have conjectured. T.

to the size of the furnace, the power of which is singularly increased by adding pipes of a certain length to the top. But too long a chimney occasions another inconvenience which we should be careful to avoid, for when the combustible parts which rise, have time to cool below the degree of heat required for their combustion, they constitute a mass, which by its weight impedes the circulation of the air.

These considerations will appear minute to some, but they may be often productive of an œconomy that is too much neglected in the arts, in which heat is employed. An attention to the circumstances of combustion merely, is not sufficient, it is also necessary to endeavour to obtain all the advantage we can from the heat that is produced, so that the whole of what is disengaged by combustion, may be as effectually as possible employed for the different purposes required.

There are some bodies which transmit heat easily, such as metals, while others on the contrary conduct it slowly, and with difficulty, such as glass, earthen ware, bricks, and particularly charcoal. On this property of charcoal, the celebrated Dr. Black, to whom we are principally indebted for our knowledge of the powers of heat, has constructed a well con-

trived furnace, which I think it right to describe, as a model capable of a great variety of application.

The furnace is composed of plate-iron, which serves as a covering, coated internally with a composition of one part argillaceous earth, and four parts charcoal ^e, of the thickness of from fifteen to sixteen lines; and in order to prevent its being destroyed by the fire, it is covered with a coat of clay mixed with sand, of about eight lines in thickness, and which is capable of resisting the action of the fire.

In the side of the ash-pit, an opening is made, to which a plate of brass is adapted, with eight holes of different diameters, to each of which is fitted a brass stopper. The admission of air by one or other of these holes produces a more or less powerful combustion, and in order to regulate it at pleasure, we have only to employ a combustible of an uniform nature, which Dr. Black finds in the coke of certain kinds of pitcoal.

The charcoal coat of the furnace prevents

^e The mixture which I have used, has consisted of nearly equal parts of charcoal dust and pure pipe clay, in which the clay was in the larger proportion. I have not been able to make a mixture in which the charcoal dust was in larger proportion adhere. T.

the loss of heat, which is almost entirely employed in producing the effect we wish: the regulation of the heat by the mode of giving access to the air, and the uniform nature of the combustible substance, enable us to calculate not only the duration and power of the fire employed in an operation, but even the quantity reserved for every particular part of the operation.

A coating of charcoal might be applied to the indigo vats, instead of wrapping them up in cloths, and also, to vessels in which we wish to preserve for a long time the heat of any liquor, for this purpose an earthen or glass vessel is preferable to a metallic one, which more easily transmits the heat to the surrounding air.

When water is reduced to vapour, it carries off a great quantity of heat, which it gives out on being again restored to its liquid form, we may therefore by covering a boiling caldron, save a great quantity of heat which might be employed for various purposes, and we might thus even procure a heat of an equable temperature, as in a water bath.

One might construct either a sand bath, which might be useful in many operations, or

a succession of caldrons which require different degrees of heat, by erecting a long furnace in such a manner that the fire being placed at one end, the flame and heated air might be carried by a horizontal flue to the other extremity of the furnace, where the chimney is placed, through which the air escapes after having given off almost all its heat.

Even the heat communicated to the chimneys in ordinary furnaces ought not to be lost, stoves and drying rooms might be placed in the situations through which the chimneys pass; but instead of trying to retain the heat in these chimneys, as is proper in furnaces, we ought to endeavour on the contrary to rob them of it; thus the part which passes through the place we wish to heat, ought to be of metal; but we should avoid carrying off the heat required for the inflammation of the combustible vapours.

After having given some idea of the phenomena of combustion, and pointed out the means of employing the heat produced to the best advantage, it remains that I should consider the different kinds of combustibles, in relation to the advantages they afford.

In order to compare the effect of different kinds of fuel, we may employ the method described by Mr. Lavoisier^d; this consists in burning each species of fuel in the same furnace with a caldron adapted to it, into which a certain quantity of boiling water is put, and what evaporates, is gradually replaced in each operation, by an equal quantity supplied by a cock. The quantities of each fuel required for the evaporation of the same quantity of water are then compared. It is obvious, that the qualities of the fuel, are proportional to the quantity necessary for the production of the same effect, we have therefore only to compare the quantity of fuel employed in each operation, with the respective price of each, in order to determine which is most advantageous, and ought to be preferred. In this calculation, it is of no consequence, whether we estimate the quantity of each fuel by weight or by measure, provided we know its price.

Instead of evaporating a given quantity of water, we should obtain the result we want, by burning either the same weight, or the same measure of each species of fuel, and afterwards comparing the quantities of water evaporated.

^d Mem. de l'acad. 1781.

As the measure and weight of fuel ought to be compared with the price it bears, and as this varies considerably in different countries, we can arrive at no invariable determination respecting that which it is most advantageous to employ; in one place, it will be coal, in another, wood or turf: the relative prices of these substances may vary in a very short time, by the opening of a canal, the working of a coal mine, or the destruction of woods.

Many artists entertain prejudices against the use of pitcoal, but it is sufficient to remark, that it is at present used in so great a number of manufactories, without producing any inconvenience, that it may doubtless be substituted for other fuel; but as in proportion to its bulk it affords much more heat, it will be necessary to learn by practice how to moderate its effects.

The construction of furnaces in which coal is to be used, should be somewhat different from that of the furnaces in common use. As it does not easily inflame, it requires a grate which may afford a passage to a current of air.

Though it should be proved by experience that no advantage would arise, in a particular country, by preferring coal to wood, still it would be proper to recommend its use, because

it is very probable that the price of wood will continue to increase, and on the contrary, that that of coal will diminish, because the working of coal mines will be encouraged, and more successfully conducted, than has hitherto been the case in France, and because we have reason to hope that the number of canals, which would facilitate its carriage, will be multiplied.

Pitcoal is reduced to the state of a true charcoal, by an operation called cokeing, which is analogous to that employed in charring wood. This charcoal is of considerable advantage in the furnaces for smelting iron ore, for the pitcoal swells and runs together when strongly heated, and thus chokes up the furnaces, inconveniences which do not attend it when reduced to coke; but for other uses, it is better to employ it in its natural state, because all the bituminous oil which is burnt during the charring, is carried off without producing any effect, and besides, the operation itself requires labour, which is attended with expence.

Peat may also be charred, but this operation presents a difficulty which is not easily surmounted: when newly charred peat is exposed to the air, it inflames spontaneously like pyrophorus; this inconvenience however may be prevented.

What has been said on the subject of pitcoal is applicable to turf; whenever we can, it is better to employ it in its natural state, than be subject to the expence of charring it, and at the same time of losing all that is consumed in that operation, which might have afforded heat.

C H A P. IV.

Of the Means of judging of the Goodness of a Colour.

AS there is a great difference in colours, with respect to their power of resisting the action of air and light; and as it is in this, that their durability and goodness chiefly consist, independant of their brightness, it is of importance, in order to secure the public confidence in the manufacture, to be able by easy means, to determine the degree of goodness in a colour. These means must have appeared of still greater importance, when the rigour of laws impeded the progress of industry, and anxiously established the distinction between the dyers of durable and of fading colours.

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By a whimsical effect of these regulations, a dyer of fading colours, might be liable to punishment for producing colours of too durable a nature.

I have but little to add to the remarks of Hellot; he informs us of the method employed by Dufay, whose observations laid the foundation of the regulations made on this subject, and examines them with considerable acuteness.

“ As we have not been able exactly to
 “ ascertain, either by the information of dif-
 “ ferent dyers, or by the perusal of the old
 “ regulations, the precise distinction between
 “ the colours of the fading and the durable
 “ kind, we are under the necessity, with a view
 “ of gaining the knowledge we want, of adopt-
 “ ing a method, which though it is the most
 “ tedious and difficult, is yet the most certain,
 “ or indeed the only one upon which we can
 “ rely. The late Mr. Dufay of the royal
 “ academy of sciences, who had been selected
 “ by government, as a person whose labours
 “ might greatly improve the art of dyeing,
 “ made experiments on the subject, by dyeing
 “ wool of all colours, and even with dyes of
 “ all sorts, used either for durable or fading
 “ colours; he even sent to the different pro-

“ vices for such as are not employed at Paris ;
“ and finally, he collected most of the different
“ substances, which he conceived might be
“ employed in the art, and tried a very great
“ number of them, investigating their good or
“ bad qualities, without paying any regard to
“ the prejudices of the dyers.

“ His first experiments were made on woollen
“ yarn, but he afterwards used pieces of
“ white cloth, which he found more suitable
“ to his purpose.

“ With a view to know what colours were,
“ and what were not durable and fading, he
“ exposed to the sun and air, for twelve days,
“ some patterns of all colours, which had been
“ dyed in his own house with known compo-
“ sitions. It appears that this time was suffi-
“ cient for a trial of them, for the durable
“ colours are not at all, or but little injured,
“ while the fading ones are almost entirely
“ obliterated ; so that, after twelve days expo-
“ sure to the heat of the sun, and the dampness
“ of the night air in summer, there can be no
“ doubt as to the class, in which each colour
“ should be placed.

“ But there still remained a difficulty, which
“ was this, that as all these colours had not
“ been exposed to the air, precisely at the
“ same

“ same time and in the same season, some
“ might have had more sun, and consequently
“ might have suffered a greater change in the
“ twelve days, than others exposed in more
“ cloudy weather, or when the days were
“ shorter. But he discovered a remedy for
“ this inconvenience, which removed all diffi-
“ culty and doubt as to the accuracy of the
“ experiments; he chose one of the worst
“ colours, that is, one on which the sun had
“ produced the greatest effect in twelve days.
“ This colour served as a standard in his expe-
“ riments, and whenever he exposed patterns
“ to the air, he always exposed a piece of this
“ stuff along with them; so that he did not
“ calculate by the number of days, but by
“ the colour of his standard, always keeping
“ the pattern exposed, till it had lost as much
“ as that would have done, by twelve days
“ exposure in summer. As he always noted
“ the day on which he exposed his patterns,
“ he was led to observe, that in winter it was
“ only necessary to leave them four or five
“ days longer exposed to the air than in sum-
“ mer. By pursuing this method, he removed
“ all doubt as to the accuracy of his expe-
“ riments. In this trial by exposure to the
“ air and to the rays of the sun, he had a
“ still

“ still further object, which was, to find the
 “ proper proof for each colour ; what is called
 “ proof (*deboulli* ^a) is the trial of a stuff with
 “ a view to discover whether its dye be per-
 “ manent or not : a pattern is boiled with
 “ alum, tartar, soap, vinegar, lemon juice, &c.
 “ and its quality is judged of, by the effect
 “ these substances produce. The proofs used
 “ in 1733 were so insufficient, that they did
 “ not even assist Mr. Dufay in discovering
 “ more certain ones, they even destroyed some
 “ good colours, while they produced very
 “ little effect upon the bad ; so that he was
 “ obliged to fix upon several, each of which
 “ serves for a great number of colours. The
 “ following is a short description of the method
 “ he pursued, in order to discover them.

“ After having observed the effect of air
 “ on each colour, whether good or bad, he
 “ tried the same stuff with different proofs,
 “ and stopped when he found one which pro-
 “ duced the same effect with the air ; then
 “ noting the weight of the ingredients, the
 “ quantity of the water, and the length of the
 “ trial, he was sure to be able to produce on
 “ a colour, an effect equal to that which the
 “ air would have produced, supposing it had

^a Sometimes called by our artists *boiling*.

“ been

“ been dyed in the same way with his ; that is,
“ according to the methods employed by the
“ dyers of true and false colours. Having thus
“ examined all the colours, and all the ingre-
“ dients employed in dyeing, he found out a
“ method, which may be considered as accu-
“ rate, of distinguishing the good or bad
“ qualities of each colour, by making, by
“ means of the proof, a sort of analysis of the
“ materials which composed it. We cannot
“ without injustice, refuse to acknowledge,
“ that the means Mr. Dufay employed, in
“ the discovery of these proofs or tests for
“ colour, are ingenious ; for the trial by air
“ and sun, cannot be made on those, where it
“ is necessary to judge immediately, whether
“ a stuff exposed to sale at a fair or elsewhere,
“ as of a true dye, be really so or not.

“ The proofs mentioned in the new regu-
“ lations, made in consequence of Mr. Dufay’s
“ memoirs, discharges in a few minutes, as
“ much of a colour, when it is not dyed of a
“ durable colour, as would be lost by twelve or
“ fifteen days exposure to the air. But as gene-
“ ral rules for such trials must be liable to many
“ exceptions, which either cannot be foreseen,
“ or though foreseen, cannot be particularized,
“ without the risk of causing confusion, or of
“ affording

“affording matter for innumerable disputes,
“it follows, that those rules considered perhaps
“as too general, are also too severe in many
“cases, wherein light colours require salts,
“or quantities of salts, which shall be less
“active than those necessary for deep or
“loaded colours (*chargées*), which may allow
“a considerable portion of their colouring
“matter to be carried off by a proof, with-
“out shewing any very visible alteration. It
“would therefore have been necessary, to
“prescribe a proof for almost every shade,
“which from their infinite variety, would be
“impossible. Thus the air and the sun, will
“always be the true test; and every colour
“which is not changed by them, in a certain
“length of time, or which, by exposure,
“acquires what the dyers call a body (*fond*)
“ought to be considered as a standing colour,
“even though it should be considerably
“changed by the proofs prescribed by the
“new regulation. Of this we have an ex-
“ample in scarlet; as soap almost entirely
“discharges this colour, it has been submitted
“to the trial by alum; and when it has been
“dyed with cochineal alone, without any
“mixture of other ingredients, it ought to
“assume a purple colour, in a boiling solution
“of

“ of alum : if scarlet be exposed to the sun, it
“ loses some of its brightness, and becomes
“ deeper ; but this deep shade is not similar
“ to that imparted by alum. Proofs then,
“ in certain cases, cannot be substituted for
“ the action of the air and sun, at least, so far
“ as respects similarity of effect.

“ By means of brasil wood, which like
“ almost all the other woods loaded with co-
“ lour, gives a fading dye, I prepared a red,
“ which was much finer than the madder reds,
“ and as bright as those made with kermes ;
“ this red remained exposed to the air for the
“ two last months of the year 1740, which
“ were very rainy, and for the two first of
“ 1741 : and notwithstanding the rain and bad
“ weather it stood, upon account of its pecu-
“ liar preparation which will be mentioned in
“ the proper place, and was so far from losing,
“ that it acquired body. Yet this same red
“ which is so durable in the air, does not resist
“ the trial by tartar. Would it then be proper,
“ to proscribe this colour, because that salt
“ discharges it, or are the stuffs we employ for
“ clothing intended to be boiled with tartar,
“ alum, or soap ? I do not however mean
“ to disapprove of the trial by proofs ; they
“ are useful, because they are ready, but there
“ are

“ are cases in which they ought not to serve
 “ as a ground for pronouncing a sentence of
 “ confiscation ; especially when they cannot
 “ shew, that a colour which should have been
 “ dyed with materials for durable colours, has
 “ been dyed with those of a fading nature.”

It is therefore evident, that there has been hitherto only one sure mode of determining the durability of colours, that is, exposure to the action of the air, sun, and dew, for a certain length of time : proofs, whatever pains may be bestowed on the choice of them, can only be applicable to the processes performed agreeably to the regulations, and not to those which have been discovered or improved since they were made.

The oxygenated muriatic acid affords a quick and easy method of determining the degree of durability a colour may possess, because it acts like the air itself : thus, when we wish to examine a colour, we need only put a pattern of the stuff into oxygenated muriatic acid, along with a pattern of the same colour which has been dyed properly ; the comparative power of resisting its action, shewn by the colours of the two patterns, becomes the measure of their goodness ; but as this liquor has a very strong action on the colouring
 particles,

particles, it must be employed in a very dilute state. This proof has also the advantage of shewing us very nearly the shades and changes through which a stuff must pass, when it comes to be acted upon by the air. Still however, were it necessary to examine a colour juridically, I should not venture to rely entirely upon the action of the oxygenated muriatic acid, and would only decide with confidence, from the results afforded by exposure to the air.

In order to try the colours of silk, it is generally thought sufficient, to expose them to heat in acetous acid, or lemon juice; and they are considered as good and permanent colours, if they stand this test; and indeed, when the woods or archil alone have been employed, the colours are made red by the action of a vegetable acid, but if the solution of tin has been used to dye with these substances, the colour which has been prepared in an acid liquor, is not afterwards affected by vegetable acids, and in that case a colour may be reputed good, which has been much less expensive, and will prove less durable; so that for silk also, we must employ the oxygenated muriatic acid, and more especially exposure to the air.

There is also another kind of proof, which seems to me very useful; it is intended for

enabling us to estimate the comparative goodness of colouring substances of the same kind. We have hitherto been confined to mere inspection, or to some other marks, which afford only uncertain indications, and could by no means furnish a scale of comparison. The oxygenated muriatic acid seems to answer this purpose, as completely as could be desired; because when we compare indigo with indigo, the nature of the colouring particles is the same, or nearly the same, and no foreign affinity can interfere, to prevent the action of the oxygenated muriatic acid from determining the proportional quantity of colouring matter.

If it should happen, that any considerable difference occurred, even in the nature of colouring particles supposed to be the same, it is very probable, that the action of the oxygenated muriatic acid would still be a measure of their comparative goodness.

When therefore we wish to compare together two or more colouring substances of the same nature, and to determine the relative quantity and quality of the colouring particles in each, we need only compare the quantities of the same oxygenated muriatic acid, required to produce the same degree of deterioration in an equal weight of each; the qualities of these substances,

stances, or the quantity of colouring particles they contain, are directly proportionate to the quantities of liquor required to produce the same effect on each; but in this experiment, it is necessary, that the colouring matter of each substance should have been dissolved in a proper liquor, and that all the circumstances in the process of comparison, should be similar.

If we wish for example to compare several kinds of indigo, we take an equal weight of each, powder them carefully, and put them into separate matrasses, with eight times their weight of concentrated sulphuric acid: these are to be kept for twenty-four hours in a heat of from thirty to forty degrees (100 to 122 Fahrenheit) for which purpose a dunghill may be employed: each solution is then to be diluted with a quantity of water, filtered, and the residua found on the filters to be collected, and ground in a glass mortar, and again digested with the addition of a little more sulphuric acid: the last solutions are also diluted with equal quantities of water, filtered, and each added to its corresponding liquor; finally, to each solution is added as much oxygenated muriatic acid as will discharge the colour, or rather bring them all to the same shade of

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yellow.

yellow. The qualities of the different kinds of indigo, are proportionate to the quantities of oxygenated muriatic acid required to destroy their colour.

The proofs of such colouring particles as are soluble in water, are much more simple ; it is only requisite after having exhausted them as much as possible, to mix oxygenated muriatic acid with equal bulks of the decoction of the same weight of each substance, and to compare the quantity of acid required to bring them all to the same hue.

Whatever uncertainty may attend the employment of the proofs prescribed by the regulations in many cases, I am very far from condemning their use entirely ; for I should think it unjust, that a colour which might strike us by a fugitive brightness, should be preferred to a standing colour, prepared at a much greater expence, and with a strict regard to honesty.

How are we to reconcile the interests of commerce, and the freedom from restraint which industry demands, with the security of the consumer ? This is a problem of difficult solution, and that requires all the prudence of the legislature ; and though a subject foreign to my present pursuit, it is perhaps my duty to
mention

mention the ideas which have occurred to me respecting it.

That part of the regulations which relates to black, ought, I think, to be retained, because the proof recommended is proper for determining whether the cloth has received a blue ground, and of what intensity that has been.

That which respects scarlet, and the shades approaching to scarlet, ought to be suppressed, as taking it for granted, that pinks (*langoustes*) for example, are to be made without employing fustic or other yellow ingredients, which is impossible, or which at least cannot be accomplished, without incurring inconveniences as great as those which would arise from the fading nature of the colour of the ingredients. With respect to these colours I conceive we may trust merely to the beauty, of which every body is a judge; because we cannot substitute any thing for cochineal, without injuring the brightness of the colour.

Soap is mentioned as the proof for greens; but we thus proscribe the Saxon greens, which do not stand this proof, but are esteemed on account of their brightness, though they are less durable than the greens dyed in the blue vat (*bleu de cuve*).

I should wish that all modes of dyeing were equally permitted, that the distinction between grain and other dyers was abolished, as it can no longer be preserved, since the ingredients allotted for false or mock colours, are now frequently employed for standing colours, that each artist might give the greatest scope to his industry and speculations; but that the public should be informed by a mark, of the colours to be relied upon as durable; that consequently, those colours which had stood the test of the proofs established by law, should be marked with a lead, declaring them to be true or standing colours, whatever process might have been employed in dyeing them;

That those which should be offered as standing or true colours, but yet should not be found capable of sustaining the prescribed proofs, should merely be reserved for the trial by exposure to the air;

That if they supported the action of the air, as well as a pattern of the same colour of known goodness, they should still be marked with the lead as standing colours;

That in such a case, which would occur but very rarely, a chemist should be employed to prepare a proper reactive for immediately distinguishing that kind of dye.

I should

I should prefer to most of the tests which have been recommended, that of the oxygenated muriatic acid, which is more simple, more indicative, and more general, being applicable to colours in silk, cotton, and wool; but I should wish, before it was adopted, that its excellence should be established, by a great number of trials made in presence of several dyers and merchants, and that the conclusions drawn from them, when the proof turned out unfavourable, should also be only provisional. The proofs prescribed in the regulations, may however be advantageously employed on certain occasions: it is possible to render them more accurate and to direct their application more judiciously, and I have not a sufficient confidence in the ideas which I have just stated, to decide, that better methods can be substituted: these considerations have determined me to mention them.

In making the proper comparison, whatever mode of trial we adopt, we ought to employ a pattern, of not only the same colour, but one which is very nearly of the same kind of stuff.

Cotton and linen stuffs, which are to be leyed, must be tried by means of alkalis.

INSTRUCTION

Respecting the Use of Proofs for Wool and Woollen Stuffs.

“ AS it has been found, that the method
 “ for proving the dye of cloth, serges,
 “ and other woollen goods, prescribed by the
 “ thirty-seventh article of the regulations for
 “ dyers of true and standing colours, published
 “ in August 1669; and by the two hundred and
 “ twentieth and following articles of the gene-
 “ ral instruction of the 18th of March 1671,
 “ for dyeing wool of all colours, and for the
 “ culture of the drugs and ingredients employed
 “ in that art, is not sufficient to supply the
 “ means of forming an accurate judgment of
 “ the goodness or badness of many colours,
 “ and that this method may moreover some-
 “ times lead to error and give rise to disputes,
 “ various experiments have been made, by
 “ order of his majesty, on the wools designed
 “ for the manufacture of tapestry, in order to
 “ ascertain the degree of goodness of each co-
 “ lour, and the proofs best suited to each.

“ For this purpose, fine wools have been
 “ dyed of all colours, both in true and false
 “ or mock colours, and have been exposed
 “ to

“ to the action of air and of the sun for a proper
 “ length of time.

“ The good colours were not at all changed,
 “ whilst the false were more or less discharged,
 “ in proportion to their degree of badness;
 “ and as no colour ought to be reputed good,
 “ but in proportion to its power of resisting
 “ the action of the air and of the sun; this
 “ proof has been the standard for deciding,
 “ respecting the goodness of different colours.

“ On the same wools, patterns of which had
 “ been exposed to the air and sun, different
 “ trials by proofs have been afterwards made,
 “ and it has been immediately perceived, that
 “ the same ingredients could not be indiscrimi-
 “ nately employed as proofs for all colours,
 “ because it sometimes happened that a colour,
 “ the goodness of which was ascertained by
 “ exposure to the air, was considerably changed
 “ by the proof, while a mock colour resisted
 “ the action of the very same test.

“ These different experiments pointed out
 “ the inutility of lemon juice, vinegar, sour
 “ water^a, and aqua fortis, on account of the
 “ impossibility of ascertaining the degree of
 “ acidity of these liquors; and it appeared to
 “ be the surest method, to use common water

^a Of this, see the preparation, chap. xii. T.

“ with

“ with ingredients of an uniform degree of
 “ strength.

“ In pursuing this object, it has been thought
 “ necessary to divide all the colours of which
 “ wool can be dyed, whether in grain or other-
 “ wise, into three classes, and to determine the
 “ ingredients to be employed as proofs of the
 “ colours comprehended in each.

“ The colours of the first class, are to be
 “ proved by roman alum ; those of the second,
 “ by white soap ; and those of the third, by red
 “ tãrtãr.

“ But it is not sufficient, with a view of
 “ ascertaining the goodness of a colour by a
 “ proof, to employ for that purpose, ingredients
 “ of an uniform power ; it is likewise necessary
 “ that the duration of the operation, and even
 “ the quantity of liquor should be fixed ; for
 “ a greater or less quantity of water, considerably
 “ diminishes or increases the activity of the in-
 “ gredients. The processes for different proofs,
 “ shall be what the following articles direct.

A R T I C L E I.

“ The proof with roman alum shall be as
 “ follows :

“ A pint

“ A pint of water with half an ounce of alum,
 “ must be put into a pan or other earthen ves-
 “ sel, which is to be placed on the fire, and
 “ when the water boils briskly, the wool to be
 “ proved must be put into it, and left to boil
 “ for five minutes; after which it is to be taken
 “ out and washed in cold water: the weight of
 “ the pattern should be about a dram.

ARTICLE II.

“ When several patterns are to be proved at
 “ the same time, the quantity of alum and
 “ water must be double or even triple, which
 “ will produce no change in the power or ef-
 “ fect of the proof, provided the proportion of
 “ alum and water be observed; so that there
 “ be always half an ounce of alum to each pint
 “ of water.

ARTICLE III.

“ The proof with white soap shall be as
 “ follows:

“ Two drams of white soap, cut into small
 “ pieces, must be put into a pint of water,
 “ and when the vessel is set on the fire, the
 “ water must be stirred about with a stick, in

“ order to make the soap dissolve; when it is
“ dissolved, and the water boils briskly, the
“ pattern of wool is to be put in, which must
“ likewise be boiled for five minutes, reckon-
“ ing from the time of putting it in, which
“ must not be till the water thoroughly boils.

A R T I C L E V.

“ When several patterns of wool are to be
“ proved together, the method prescribed
“ Art. II. must be observed; that is to say,
“ to each pint of water, two drams of soap
“ must always be added.

A R T I C L E VI.

“ The proof with red tartar, is to be made
“ precisely in the same way, and with the same
“ quantities and proportions, as the proof with
“ alum; taking care, however, to powder the
“ tartar well, before it is put into the water,
“ that it may be entirely dissolved before the
“ pattern of wool is put in.

A R T I C L E VII.

“ The following colours must be proved
“ with roman alum, viz. crimsons of all
“ shades,

“ shades, venetian scarlet, flame-coloured scar-
 “ let, cherry-coloured and other shades of scar-
 “ let, violets and gridelins, *gris de lin*, of all
 “ shades, purples, pinks (*langoustes*) jujubes,
 “ pomegranate flower, blues, slate grays (*ar-*
 “ *doisés*) lavender grays (*lavandés*) *violents*,
 “ *vineux*, &c.

ARTICLE VIII.

“ If, contrary to the regulations respecting
 “ dyes, any ingredients for mock colours shall
 “ be employed in dying fine wools of a crimson,
 “ the deception will be easily discovered by the
 “ alum proof, which only deepens the fine
 “ crimson, that is, gives it a gridelin tinge,
 “ while it destroys the lighter shades of the
 “ false crimson; so that this proof distinguishes
 “ with certainty, the mock from the true crim-
 “ son.

ARTICLE IX.

“ The kermes or grain scarlet, commonly
 “ called *venetian scarlet*, is not at all injured
 “ by this proof; it deepens the flame-co-
 “ loured or cochineal scarlet to a purple,
 “ and makes the low shades more intense,
 “ so

“ so that they acquire a gridelin tinge. It
 “ almost entirely destroys the false brasil scar-
 “ let, and reduces it to a colour resembling
 “ the outer coat of an onion: on the deep
 “ shades of this false colour, it produces a still
 “ more sensible effect.

“ The same proof almost entirely destroys
 “ all the shades of the scarlet dyed with *bourre*.

ARTICLE X.

“ Although violet is not a simple colour, but
 “ is made up of shades of blue and red, it ne-
 “ vertheless is so important a colour, that it
 “ deserves a particular examination. The
 “ roman alum proof produces scarce any ef-
 “ fect on the fine violet, while it very much
 “ injures the false; but it is necessary to ob-
 “ serve, that it does not always discharge the
 “ colour of the false violet in an equal degree,
 “ because sometimes that colour has been pre-
 “ pared by a ground of pastel or indigo, and
 “ this ground being a standing dye, is not re-
 “ moved by the proof; the redness however is
 “ effaced, the brown shades become almost
 “ blue, and the pale shades of a disagreeable
 “ colour resembling wine lees.

ARTICLE

ARTICLE XI.

“ With regard to the half grain violets, prohibited by the present regulation, they are to be classed with the false violets, and are equally incapable of resisting the proof.

ARTICLE XII.

“ The good gridelins may be distinguished from the bad in the same manner, but the difference is slight; the former only lose a little less than those dyed of a mock colour.

ARTICLE XIII.

“ The good purples stand the proof by alum perfectly, whereas the bad lose the greatest part of their colour.

ARTICLE XIV.

“ The colours of langouste (*pinks*) jujubes, pomegranate flowers, will incline to purple after the proof, if they have been dyed with cochineal, but will grow considerably paler, if
“ fustic,

“ fustic, the use of which is forbidden, has
 “ been employed.

ARTICLE XV.

“ Good blues, whether dyed with pastel or
 “ with indigo, lose none of their colour, while
 “ the mock colour is in a great measure dis-
 “ charged.

ARTICLE XVI.

“ Slate grays (*ardoisés*) lavender grays (*la-
 “ vendés*) *violents*, *vineux*, lose almost the whole
 “ of their colour, when of the mock kind;
 “ but remain perfectly unchanged when good.

ARTICLE XVII.

“ The following colours are to be proved
 “ with white soap; viz. yellows, jonquilles,
 “ lemon and orange colours, and all those
 “ shades that incline to yellow; all the shades
 “ of green from the yellow green (*pomona*
 “ green) *verd naissant* to cabbage and parrot
 “ green (*verd de perroquet*) madder reds, cinna-
 “ mon, and snuff colours, and the like.

ARTICLE

ARTICLE XVIII.

“ This proof shews perfectly, whether yell-
 “ lows and the shades allied to them, are true
 “ or mock colours, for it carries off most of
 “ their colour when they have been dyed with
 “ french berries (*graine d’Avignon*) ^b, annotta ^c,
 “ turmeric ^d, fustick (*fustet*) ^e, or saffron, the use
 “ of which for true colours is prohibited; but
 “ it does not change the yellows dyed with
 “ saw-wort (*sarette*) ^f, dyers broom (*genestrolle*) ^g,
 “ bois jaune ^h, weld (*gaude*) ⁱ, and fenugreek ^k.

ARTICLE XIX.

“ The same proof will also discover com-
 “ pletely the goodness of greens, for the mock
 “ ones lose almost the whole of their colour,
 “ or become blue, if they have had a ground
 “ of indigo or pastel; but those of the true
 “ kind lose scarce any of the colour, and re-
 “ main green.

^b *Rhamnus infectorius*.—^c *Bixa orellana*.—^d *Curcuma longa*.—^e According to the author, *Rhus Cotinus*, vide notes to pages 268 and 281, Vol. II.—^f *Serratula tinctoria*.—^g *Genista tinctoria*.—^h *Morus tinctoria*. Called by our botanists and dyers *fustic*.—ⁱ *Reseda luteola*.—^k *Trigonella fœnugrecum*. T.

ARTICLE XX.

“ Pure madder reds do not lose any of their
 “ colour by the proof with soap, which even
 “ renders them more beautiful; but if brasil-
 “ wood has been mixed with it, they lose co-
 “ lour in proportion to the quantity of it which
 “ has been employed.

ARTICLE XXI.

“ Cinnamons, snuff colours, and others of
 “ the same kind, are scarcely affected by this
 “ proof, when good, but lose much of their
 “ colour, if annatto, fustic, or *fonte de bourre*,
 “ have been employed.

ARTICLE XXII.

“ The proof by alum can be of no use and
 “ may lead to error with respect to many co-
 “ lours of this second class, for it does not
 “ injure fustic or annatto, which cannot resist
 “ the action of the air, but carries off a part
 “ of the colour of saw-wort and of weld, which
 “ notwithstanding, give very good yellows and
 “ greens.

ARTICLE XXIII.

“ All fawn and root colours are proved with
“ red tartar: under this title are included all
“ those colours which do not proceed from
“ the five primitive colours; they are made
“ with walnut peels, walnut-tree root, alder¹
“ bark, sumach or roudoul, sanders and foot;
“ each of these ingredients affords a great num-
“ ber of different shades, all of which are com-
“ prehended in the general name of fawn or
“ root colour.

ARTICLE XXIV.

“ The ingredients mentioned in the pre-
“ ceding article are all good, except sanders
“ and foot, which are somewhat inferior, and
“ which make the wool harsh, when employed
“ in too large a quantity: all that the proof
“ therefore can do in these cases, is to shew
“ whether they have been overloaded with san-
“ ders or foot, for then, they lose considerably
“ by the proof with tartar: and if they have
“ been dyed with the other ingredients, or
“ with the addition of a moderate quantity of
“ sanders or of foot, they stand much better.

¹ *Rhamnus frangula*. T.

ARTICLE XXV.

“ As black is the only colour which cannot
 “ be referred to any of the three classes above-
 “ mentioned, since it is necessary to employ
 “ a much more active proof to discover whether
 “ the wool has had a deep blue ground, agree-
 “ ably to the regulations, the proof is to be
 “ made in the following manner: an ounce of
 “ roman alum, and as much red tartar, in the
 “ form of powder, are to be put into a pound
 “ or pint of water, and the whole made to
 “ boil, the pattern of wool is to be put in,
 “ and a brisk ebullition continued for a quarter
 “ of an hour, it is then to be washed in cold
 “ water, when it will be easy to discern whether
 “ it has had the proper blue ground, for if so,
 “ the wool will remain of a blue colour ap-
 “ proaching to black, but if otherwise, it will
 “ become very gray.

ARTICLE XXVI.

“ As it is customary in some cases to brown
 “ colours with galls and copperas, and as this
 “ operation called browning, *bruniture*, which
 “ ought to be permitted in dyeing durable co-
 “ lours, may produce particular effects in the
 “ proofs of these colours; it is to be ob-
 “ served

“ served that though after the boiling, the li-
 “ quor should appear loaded with the dye,
 “ from its having carried off the browning, the
 “ wool is nevertheless to be considered as dyed
 “ properly, if it has retained its body; if on
 “ the contrary, it loses its body, or its ground
 “ of colour, it must be declared a mock co-
 “ lour.

A R T I C L E XXVII.

“ Although the browning with galls and cop-
 “ peras is of a durable nature, yet as it com-
 “ monly renders the wool harsh, it is proper
 “ rather to employ as much as possible the use
 “ of the indigo or pastel vat.

A R T I C L E XXVIII.

“ The common grays dyed with galls and
 “ copperas ought not to be submitted to any
 “ trial by proofs, because they are true co-
 “ lours, and cannot be dyed otherwise; but
 “ care must be taken to gall them first, and to
 “ add the copperas to a second bath not nearly
 “ so hot as the former, because in this way, they
 “ are rendered more beautiful and more fixed
 “ *assurés*.”

SECTION III.

Of Chemical Agents employed in Dyeing.

CHAPTER I.

Of Acids.

ACIDS are known by their sharp taste, by their reddening the blue colour of some vegetables, such as that of turnsole, and syrup of violets, and by the effervescence they occasion when mixed with calcareous earth and alkalis not in a caustic state.

A great number of acids are already known, and probably many more will be discovered by chemists, but we shall speak only of those which are used in dyeing, and we shall describe only those properties, which it is necessary to know, in order to appreciate their action or direct their use in this art.

ARTICLE I.

Of the Sulphuric or Vitriolic Acid.

THE pure sulphuric acid is without smell, without colour, transparent like water, and has
an

an unctuousity resembling oil, when it is concentrated; whence it has the name of oil of vitriol, an appellation which might lead to some mischievous mistakes respecting its nature.

This acid was formerly obtained from the sulphat of iron, or vitriol of iron, by distilling it with a strong fire, whence it had the name of vitriolic acid; but at present, almost all that is used in the arts, is obtained from sulphur by a much less expensive process. This acid is the result of the combustion of sulphur, which, while it burns, is combined with the base of vital air or oxygen, which exists in atmospheric air, and in nitre, of which last a certain quantity is added to the sulphur^a. The mixture of sulphur and nitre is inflamed, and the vapours are received in a chamber, the inside of which is lined with lead, and the bottom of which is covered with water; the vapours which are collected, and unite with the water, form sulphuric acid, which is to be considered as sulphur completely burned.

The sulphuric acid, on being taken from the leaded chamber, is not in a concentrated state, but is mixed with a certain superabundance of

^a Mr. de Morveau has pointed out a process in which nitre is dispensed with (*Encyclop.* pag. 359.); and it appears that a similar process is in use in England. *Journal de Phys.* Septembre 1790.

water, and it has the smell of the sulphureous acid, which differs from sulphuric acid in not being saturated with oxygen; it contains likewise a little nitrous acid, which comes from the nitre which had been mixed with the sulphur. If it be exposed for some time to the air, the smell of the sulphureous acid is diffipated; but to remove this smell, and a part of its water at the same time, it is evaporated in open vessels.

A very small quantity of vegetable or animal substance gives the acid a brown colour, and what is met with in the market, is never quite limpid; but it may be made so, by boiling it a little while in a retort. By this operation, we take away at the same time a portion of nitrous acid, which is met with in the common sulphuric acid, and a portion of water; it becomes colourless and transparent, and the concentration is proportioned to the quantity of water that has been distilled from it. If we wish to have it perfectly pure, it is necessary, after having separated the first portion which is weakly acid, to continue the distillation to dryness, when there remains a little alkali, which came from the nitre, and which is united with an excess of sulphuric acid, a combination known by the name of *acidulated sulphat of pot-ash*;

pot-ash; there is often found likewise a little sulphat of lead.

For this rectification we ought to choose a low necked retort, and to fix it well in the furnace, that the motion which the ebullition of the acid occasions, may not break it. If this accident should take place, it is proper to withdraw ourselves to a distance quickly, in order to avoid the sulphureous vapours which are evolved in abundance, when the acid falls upon the burning coals.

The sulphuric acid attracts strongly the humidity of the air, and to preserve it in a concentrated state, it must be kept in vessels of glass closely stopped.

When it is mixed with water, a great degree of heat is produced, so that the mixture must be made gradually, lest the vessel should break. To make the mixture complete, it is necessary that the liquor be well stirred with a glass rod, for notwithstanding the strong attraction of this acid for water, the difference in the specific gravity of the two fluids, is an obstacle to their mixture.

The sulphuric acid highly concentrated, has a specific gravity nearly double that of distilled water. When it is weak, that is, diluted with
a good

a good deal of water, the fallacious name of *spirit of vitriol* is given to it.

* In order to obtain uniform results, it is right to employ for the same operations, sulphuric acid of the same degree of concentration. Its specific gravity may be ascertained by the areometer of Fahrenheit, but it is more expeditious, and it is sufficient to employ that of Mr. Baumé, which is so well known.

The acid is to be put into a cylinder of glass, and the areometer for salts is to be immersed in it; the heavier the liquor is, the less is the areometer immersed, and the degree of the scale even with the surface of the liquor, points out the degree of concentration. Sixty-eight degrees of this areometer point out a highly concentrated sulphuric acid ^b.

Hitherto we have used the sulphuric acid in dyeing, only to dissolve indigo, and for this purpose, a very concentrated and pure acid is required; but a good deal is employed to prepare cotton stuffs for printing, and in the bleaching of linen and thread, either by the

^b This degree, estimated by one of those instruments which I got from France, but the accuracy of which I cannot answer for, corresponds to 1,840, the specific gravity of distilled water being taken as 1000. T.

oxygenated muriatic acid, or by exposure on the grafs. It has not been yet used in France for this last purpose, though it has in England a long time, according to Dr. Home; and the experiments which have been made in bleaching by the oxygenated muriatic acid, prove that it may be substituted for sour milk, which is usually employed in this country.

For these last purposes, a very concentrated sulphuric acid is not required; if then, we are in the neighbourhood of a manufacture of sulphuric acid, it is more advantageous to buy it before it has been concentrated, and to save the expence of this operation; but if at a distance from such a manufacture, it may be more advantageous, by lessening the expence of carriage, to purchase it in a concentrated state.

Sulphuric acid forms different compounds with alkalis, earths, and metallic substances. In order to point out the acid principle in these compounds, the name of sulphats is given to them; thus the combination of the vegetable alkali or pot-ash, is called sulphat of pot-ash. We shall hereafter treat particularly of the sulphats which are used in dyeing; at present we shall mention two, the names of which sometimes occur in works on that art.

The

The fulphat of pot-ash or vitriolated tartar, has a bitter and biting taste : it requires sixteen parts of water at sixty degrees of Fahrenheit to dissolve it : it is contained in the ashes of many vegetables. Hellot considered it from its small solubility, as proper for fixing colours in the pores of cloth ; but this opinion is unfounded. It has little action upon the colouring particles.

Sulphat of soda or Glauber's salt, is much more soluble than the former ; it effloresces, that is, it parts with its water of crystallization to the air, and assumes the appearance of flour. It is found naturally in some subterraneous places, and in some waters, so that it is obtained from the residua of the waters, which are evaporated in the salt works of Lorrain. It is this salt which is usually sold under the name of salt of Epsom ; but Epsom salt is a fulphat of magnesia and not of soda.

The sulphat of lime, or the combination of lime with sulphuric acid, abounds in nature. It is this which forms gypsum, or plaster of Paris. It requires near five hundred times its weight of water to dissolve it, at twelve degrees of Reaumur (59 Fahrenheit).

ARTICLE

ARTICLE II.

Of Nitrous Acid.

CHEMISTS have given different names to this acid, according to the processes by which it is obtained from nitre; they have called what is obtained from a mixture of nitre and clay, *aqua fortis*; what is obtained by distilling nitre with fulphat of iron, *spirit of nitre*; and what is procured from a mixture of nitre and sulphuric acid, *smoking nitrous acid*. These distinctions are not made in trade, and the name of *aqua fortis* is equally given to this acid by whatever process it has been made. In fact, it is always the same acid, and it differs only in its concentration and in its colour; sometimes it is pale, sometimes red and smoking: it owes its colour and property of smoking to nitrous gas, which it holds in solution, as we shall explain hereafter.

If we expose the reddest acid to a sufficient heat, the nitrous gas is separated, and the acid becomes pale. It is in this state called *nitric acid*, and in its red state it is called *nitrous acid*.

As there is no great consumption of nitrous acid in the art of dyeing, and as this is carried on very frequently at a distance from any manufactures of the acid, it may be convenient and may save expence, for the dyer to prepare it himself. I shall on this account describe the process for obtaining it from nitre, by means of the sulphuric acid.

We powder pure nitre, called nitre of the third boiling, because it is the result of the third crystallization; we put it with half its weight of strong sulphuric acid into a retort, which is chosen of such a size, that it shall be only half filled, so that the matter during its bubbling, may not be forced into the receiver; we fix to the neck of the retort a bent tube, the orifice of which, is large enough to admit the neck of the retort; we introduce the extremity of this tube, which should have a much smaller diameter, through a cork, into a receiver with two necks; to the other neck of the receiver, we fix a tube which is to be immersed in a little water contained in a matras, which is to serve as a second receiver. The joints of the retort with the first tube, and of the first receiver, should be smeared and carefully stopped with a greasy lute, composed of white clay and linseed oil, which has been

been boiled with a little litharge (this lute should be beaten for a long time in a mortar, to render it pliant and ductile) and then covered with slips of linen soaked in white of egg, and sprinkled with powdered lime. It is advantageous to use a tubulated retort, and to have the whole apparatus prepared, before the sulphuric acid is introduced by the opening in the upper part of the retort.

The second receiver should have a free communication with the air, in order that the vapours, which could not be condensed in the water, may escape. The quantity of water put into the second receiver, should be proportioned to the quantity of acid we are preparing. The fire should be kept very low at the beginning, and increased slowly toward the end of the operation. The acid obtained in the first receiver is highly concentrated; that in the second, is weakened by the water in which the acid vapours are condensed. The colour of the latter is green or blue: these colours are owing to the nitrous gas, and their difference depends upon the proportion of water, so that if a little water be added to what is green, it turns it blue; if the gas be expelled by heat, the liquor becomes pale. The acid in the second receiver is always pure; but that

in

in the first sometimes contains some sulphuric acid, which may happen when the fire has not been kept sufficiently low at the beginning of the operation; for I have frequently found that when the fire has been carefully regulated, the acid has been perfectly pure.

It is of importance to examine the nitric acid prepared for sale, because it often contains a considerable quantity of sulphuric acid, either from the distillation having been conducted carelessly, or from its having been added purposely, to increase the specific gravity of the nitrous acid. The examination is made by diluting a small quantity of it with distilled water, and adding a little of the solution of barytes or heavy earth in nitric acid. If any sulphuric acid is contained, a precipitation takes place, because the sulphuric acid separates the barytes from the nitric acid, and forms with it an insoluble compound. The nitric acid may also contain muriatic acid, from the common salt which is often met with in nitre. This mixture is not injurious in any of the operations of dyeing; if, however, we wish to know, whether it exists or not, the nitric acid is to be diluted with distilled water, and a little of the solution of silver in nitric acid added; if there be any muriatic acid, a precipitate is let fall.

In

In order to free nitric acid from sulphuric acid, it may be redistilled from a little nitre, or from a solution of lead: the latter method also purifies it from muriatic acid.

The nitric acid may be employed for many metallic solutions, the use of which, as mordants, may be various; but it is principally employed for making aqua regia, or the nitro-muriatic acid, which will be treated of in a separate article.

It is necessary, in order to understand a great variety of phenomena, that we should form a just idea of the nature of nitric acid, and of its action upon other substances.

The nitric acid is composed of two substances, which, when separate, assume an elastic, acrid, or gaseous state; they are the two gases which constitute our atmosphere. One is incapable of supporting life and combustion; this is the *azotic gas* or *phlogisticated air*; the other alone serves combustion, is the principal source of the light afforded by it, and maintains, in a remarkable degree, the life of animals that breathe it, whence it is called *vital air*; it is also called oxygenous gas, because when it becomes fixed in many substances, it communicates to them acid properties.

Azot and oxygen which have lost their elasticity, and which are combined in favourable circumstances, form the nitric acid; but these two substances may unite in various proportions, and upon these proportions depend the different states in which the acid is observed.

Azot completely saturated with oxygen, forms a colourless nitric acid; the azot is then in the proportion of about a fifth part of the weight of the oxygen; if the proportion of the azot be much greater, and nearly equal to that of the oxygen, nitrous gas is formed, which by itself, is in an elastic state, but which may be dissolved in large quantity in the nitric acid; this is the gas, which, by its solution, gives to the acid a colour of any shade from pale yellow to deep red, and changing into green and blue by the addition of water; this gas attempting to escape and to combine with the air of the atmosphere, produces the red vapours of the nitrous acid.

The nitric acid sometimes enters into combination without being decomposed; this is the case, when it unites with alkalis and some earths; sometimes it is decomposed, because the oxygen is taken from it by another substance: this happens with metallic solutions; if the metal acts
strongly

weak. It is obtained likewise by distilling sea salt with sulphuric acid. As it fetches so high a price in France, that a great part of that which is sold at Paris, and even sent to Lyons, comes from England; and, as we may be often at a considerable distance from the places in which it is prepared, I shall describe a method by which it may be advantageously obtained.

This process is very similar to that which has been described for obtaining the nitric acid. I shall content myself with pointing out the differences.

The retort to be made use of, should be tubulated. The salt is introduced into it, and afterwards half its weight of sulphuric acid. The upper opening should be stopped quickly ; the rest of the apparatus should be prepared before. It consists of two bottles, into which a quantity of water, equal in weight to that of the salt employed, is put ; but as the vapour which is separated, is very miscible with water, a vacuum is very apt to be formed, which occasions the liquor of the second, to pass into the first, and from this into the retort. To avoid these inconveniences, the first bottle should be furnished with a tube of safeguard, invented by Mr. Welter. This is a tube of glass of two or three lines diameter, one ex-

tremity of which reaches to the surface of the water which has been put into the bottle, and the other communicates with the atmosphere. This tube is introduced by a separate opening, or still better, by one of the corks through which the tube of communication passes.

If a vacuum be formed, the atmospheric air gets into the bottle; but while the vapour is separated, and presses upon the liquor, this is raised in the tube, until the weight of the column counterbalances the pressure of the vapour. It should be carefully luted, because the vapours of muriatic acid are very penetrating, and when they have made a passage through the lute, it is very difficult to stop it. If however this accident happens, the best method of remedying it, is to rub the place where the acid issues with alkali, in order to saturate the acid, and to apply lute to it immediately. We should wait till the effervescence produced by adding the sulphuric acid be over, before we put fire underneath the retort, which should be placed in a sand bath, and the fire should be kept very low, especially at the beginning of the operation.

The acid in the first bottle is very concentrated and smoking. It sometimes contains

^c Ann. de Chym. tom. ii.

fulphuric

fulphuric acid, which is discovered by diluting it with distilled water, and adding a little of the solution of barytes, which produces a precipitation. If we mean to purify it, it should be redistilled from a little common salt.

The acid of the second bottle is much less strong; if it be too weak for the purposes it is intended for, it may be used instead of water for a second distillation: it has the advantage however, of being pure.

Muriatic acid may be employed for various metallic solutions, which may be used as mordants; thus the solution of tin or the muriat of tin, may be useful on many occasions. In order to prepare this salt, tin should be dissolved by the assistance of heat, in a strong muriatic acid, and the liquor should be evaporated till all the salt which will crystallize is separated. Mr. Baumé relates that he has prepared large quantities of this salt for printing linens. I do not believe that it is at present employed for that purpose. The muriat of lime, and that of magnesia, acts upon colouring substances, as other salts of earthy basis.

The muriat of soda or common salt, which is obtained from sea and other salt water, has a remarkable action upon colouring bodies;

in general, it tends to deepen their shade and to render them more fixed.

Sal gem is the common salt obtained from mines which are found in the bosom of the earth.

Muriat of ammoniac or sal ammoniac, is composed of muriatic acid and ammoniac or volatile alkali. A great quantity of this salt is brought from Egypt, where it is prepared; it is manufactured likewise in many parts of Europe. That which comes from Egypt is darker than what is made in Europe, and it is soiled with soot, so that it is less pure, and consequently less fit for dyeing. Nevertheless many artists prefer it. Sal ammoniac dissolves easily in water, and crystallizes by evaporation, in quadrangular prisms terminated by quadrangular pyramids. These crystals have a flexibility, which enables them to bend in any direction without breaking. Sal ammoniac renders colours in general deeper and more saturated.

Mercurial muriat or corrosive sublimate, is the compound of muriatic acid with mercury, containing a great quantity of oxygen. This preparation is made by various processes, which all agree in combining mercury with oxygen, and uniting it in this state with muriatic

atic acid. This salt acts upon many colours, rendering them deeper, more dusky, and more fixed.

It may be considered as a general property of muriatic salts, to render colours deeper and more fixed.

ARTICLE IV.

Of Oxygenated Muriatic Acid.

THE muriatic acid assumes entirely new properties when it is combined with oxygen: its taste is rough, instead of being acid; its smell is very penetrating; it loses with difficulty its state of gas, and does not combine readily with water: when water is saturated with it at a low temperature, it becomes solid. It has a powerful action upon colours, but different from that of acids. It at length destroys them.

We may easily satisfy ourselves that these new properties depend upon the oxygen or base of vital air, by exposing a phial filled with this liquor, to the light of the sun, furnished with a bent tube, which passes under an inverted jar filled with water. For we see
small

small bubbles issuing from all parts of the liquor, and collecting in the jar; and if this gas be examined, it is found to be vital air, or oxygenous gas, and the liquor which remains in the phial is common muriatic acid.

I have described ^d the process by which great quantities of oxygenated muriatic acid, for bleaching thread and linen cloth, are prepared, as well as the operations employed in the bleaching; but there are cases in which this acid may be useful in dyeing, and it may be foreseen, that the application of this powerful agent will become more general. I shall therefore describe the process, by which a small quantity of this acid may be obtained, and where we do not mean to use the apparatus which is employed in preparing it for commerce, a description of which is found in the *Annales de Chymie*.

A retort with a bent neck, or which has a bent tube fixed to it, must be fitted to a bottle with three openings, to one of which the tube of safeguard already described, must be fixed, and immersed in a little water. In addition to the first, which should be small, three more bottles should be employed, which should stand one behind another and communicate by tubes;

^d Ann. de Chym. tom. ii.

each tube of communication should open into the upper part of the bottle which precedes it, and into the middle of the bottle which follows it ; the three last bottles should be almost filled with water, and have each a tube of safeguard, except the last, which ought to have a free communication with the air.

The retort should be tubulated ; or instead of a tubulated retort, a matrafs may be employed, which is made to communicate by a tube with the first bottle. All the tubes should communicate in the inside of the vessels by stoppers of cork, which fit well, and which should be covered very carefully with a greasy lute, or with one still more convenient, which is composed of equal parts of linseed meal, and almond paste (*pate d'amende*) to which a proper consistence is given by starch. We may see if the gas has got issue, by presenting the mouth of a phial filled with ammoniac to the different parts which are luted ; for if any vapours escape, a white cloud is formed.

When the apparatus is prepared, we introduce into the retort by its superior opening, or into the matrafs, five ounces of sea salt, and an ounce and half of oxyd of manganese powdered, and well mixed with the sea salt ; we then add four ounces of concentrated sulphuric acid, previously

viously mixed with an equal quantity of water ; for this quantity of ingredients the three bottles should contain from twelve to sixteen pints of water (about sixteen quarts English).

At the beginning, the fire for the distillation should be very low, and it should be increased slowly ; towards the end of the process the liquor should boil. We know when the operation is nearly finished by the degree of heat communicated to the first matrafs, which is intended to receive the unoxxygenated muriatic acid.

The liquor which is in the first of the large bottles, is of a yellow green colour, it is much stronger than that in the second bottle ; that in the third is very weak. The mixture of the three liquors is sufficiently strong for most operations. It should be kept in a bottle well stopped, and not exposed to the rays of the sun.

The apparatus I have described, as well as that I have proposed for operations on a large scale, may be executed in different ways : the chief object is to facilitate the combination of the disengaged gas with the water, by extension of surface, by pressure, and even by agitation.

The oxxygenated muriatic acid, as has been already explained, may be employed as a test

strongly upon the oxygen, it takes up the whole of it, and azot is separated by itself, in the form of gas; but commonly it takes only a part of the oxygen, and the other part forms the combination which escapes in the state of nitrous gas. hence arises the effervescence which the nitrous acid produces with metals.

In like manner the nitrous acid may act merely like an acid upon colouring substances, without undergoing any decomposition; but a part of the oxygen is taken from it sooner or later by these substances, and they then undergo changes, analogous to those which they would suffer in combining with the oxygen of the atmosphere, and which are the result of a true combustion.

We should guard against the prejudices which have prevailed, respecting the vapours which are separated by metals from the nitric acid, and the strength of this acid when it has become smoking. It is easy to make it smoke, by adding a little iron, or any thing that can furnish nitrous gas; it must have indeed a certain degree of strength, to become smoking, but, at the same time, it may be very concentrated, and have no colour.

The nitrat of pot-ash is, as its name expresses, a combination of nitric acid with pot-ash. This

salt is obtained from old mortar and artificial mixtures of rubbish, in which it is formed by the concurrence of atmospheric air. It has little action upon colouring substances; nevertheless, it renders their colours a little more clear and lively.

The nitrat of lime and that of magnesia are among the salts of earthy basis, which are found in many waters, and, like those waters, tend to give a deeper shade to many colours.

A R T I C L E III.

Of the Muriatic or Marine Acid.

THIS acid is commonly known under the name of marine acid, or spirit of salt; it has a peculiar smell, resembling that of saffron; when it is concentrated, it gives out white vapours to the air, which are produced by the combination of this acid, with the water which is contained in the atmosphere. When it is saturated with water, it ceases to afford vapours; it has usually a yellow colour, but this is derived from a little iron; when it is quite pure, it is colourless as water.

This acid is obtained for commerce, by distilling sea salt with clay; but it is then always weak.

of the durability of colours, and for comparing the goodness of colouring substances of the same kind. It is used for whitening the ground of some printed linens; it may be used to destroy the colours of pieces which have suffered some accident in dyeing, or which have been spoiled by keeping, and thus fit them for receiving a new dye; but it leaves a yellow colour in wool and silk. Linens are completely whitened by it, unless iron entered the composition of the mordant used in dyeing them; in which case they should be passed through water acidulated by sulphuric acid. If the colouring particles have not been entirely removed, a weak ley will dissolve them.

Some persons use the oxygenated muriatic acid to brighten several colours, and to render them clear. I do not know exactly their method; I only know that it is often useful in this case to employ oxygenated muriatic acid united to pot-ash. To obtain this species of combination, from four to five ounces of common pot-ash should be dissolved in a pound of water, and only the bottle which contains this solution is to be placed after the matrafs intended to receive the acid which is not oxygenated; the alkali renders the absorption of the gas easy.

ARTICLE V.

Of Aqua Regia, or the Nitro-muriatic Acid.

THIS compound acid has received the name of aqua regia, because it possesses the property of dissolving gold, by some styled the king of metals: but with regard to its nature, we ought to consider it as a mixture of the muriatic and nitric acids, which combine their powers to produce solutions, that separately they were unable to effect. Their mode of action I have elsewhere explained^c.

The nitro-muriatic acid may be prepared either by simply mixing together nitric acid and muriatic acid, or by dissolving ammoniacal muriat, or muriat of soda, in nitric acid. We might make use of other salts, nitre, or nitrat of pot-ash, for instance, dissolved in muriatic acid, and employ many other processes, which it would be superfluous to mention.

We shall examine the nitro-muriatic acid chiefly with respect to the solution of tin, as that is the principal use made of it in dyeing.

^c Mem. de l'acad. 1785.

The dyers do not all prepare the solution of tin, to which they give the name of composition, in the same way: every one has his receipt. The effects produced by the solution, however, are different, according to the manner in which it is prepared: it is of special consequence therefore, that the same artist prepare it always in the same manner, in order to obtain uniform effects, his observations on which, may serve to guide him in his subsequent operations.

Several dyers use merely the common aqua fortis of the shops, which is a kind of nitromuriatic acid; as it is prepared from an impure nitre, which is mixed with a greater or less quantity of marine salt: this quantity, however, being various, and the concentration of the aqua fortis also subject to great variation, its effects must be uncertain.

Pure nitric acid attacks tin with violence, and reduces it to an oxyd or calx, of which little remains dissolved; so that, if the aqua fortis should happen to be pure, the solution made with it would not be fit for use. Yet Mr. Vogler asserts^f, that the nitric acid is the best solvent of tin. Supposing him to have employed pure nitric acid, I should endeavour

^f Crel. chemisch. ann. 1785.

to explain his opinion, which is contrary to the experience of every other chemist, by the manner in which he treated the tin: this he reduced into plates, and, by the kind of hardening which he thus gave it, he defended it, as it were, from the too violent action of the nitric acid, and rendered it but little soluble in the nitro-muriatic acid; for, according to him, the latter dissolves it with difficulty, though every other chemist has found the contrary. Mr. Vogler observed, that his nitric solution readily became a jelly: this is a considerable inconvenience; for the greater part of the jelly is precipitated in water, instead of dissolving in it. The formation of this jelly he prevented, by mixing with the nitric solution from a tenth to a fifteenth part of muriat of soda, or ammoniacal muriat dissolved in water: but he might as well have employed at once the nitro-muriatic acid, which easily dissolves the tin, and is not liable to those inconveniences which occur when we attempt to make the solution with nitric acid alone.

Hellot took eight ounces of nitric acid, which he mixed with an equal quantity of filtered water. In this mixture he dissolved gradually half an ounce of very white sal ammoniac, and two drams of pure nitre, and afterwards half

an ounce of grain tin. Scheffer dissolved one part of tin in four parts of nitro-muriatic acid^a. Macquer dissolved three parts of tin in eight parts of nitric acid, with which he mixed one part of sal ammoniac and six parts of water. Mr. Poerner put an ounce and half of sal ammoniac into a pound of nitric acid mixed with a pound of water, and in this liquor he dissolved two ounces of tin. Mr. Guhliche mixed a pound of fuming nitrous acid with a pound of water and two ounces of sal ammoniac, and this liquor he saturated with as much tin as it could dissolve, adding it by small quantities at a time^b. The proportion of tin in this case was more considerable than those before mentioned.

It is obvious, that these solutions, which I have taken only from those who have written on the art of dyeing, must have very different properties: in all, there is an essential defect; the preparation is not constantly uniform. To obviate this, it is indispensably necessary to employ a pure nitric acid, and to ascertain its specific gravity by means of the areometer. After many trials, which it would be useless to relate, the process by which I have obtained

^a Essai sur l'art de la Teinture.

^b Vollständiges Farbe und Bleichbuch, &c. Band. iv.

the solution that gave me the most beautiful colour with cochineal, both on wool and silk, and that will also keep the longest without the formation of a gelatinous precipitate, consists in taking nitric acid at thirty degreesⁱ, dissolving in it one eighth of its weight of muriat of ammoniac, adding by small portions an eighth of its weight of tin, and afterwards diluting the solution with a fourth of its weight of water.

A pure tin, such as that of Malacca, or good english tin, should be chosen, because the common tin contains copper and lead, each of which is prejudicial to the beauty of the colour. There is some copper even in the fine english tin: but the common tin sometimes contains near half its weight of lead, and also, antimony and bismuth^k. The tin should be grained, by melting it, and pouring it into water agitated with a bundle of small rods. This operation ought to be performed cautiously, to prevent the tin from splashing about.

In general a small quantity of a blackish

ⁱ This I find by an experiment similar to that mentioned page 212, makes the specific gravity of this acid compared with distilled water as 1,240 to 1000. T.

^k Recherches sur l'E'tain; par M M. Bayen & Charlard.

sediment is formed, from which it is necessary to decant the solution.

The solutions which contain a large proportion of tin are brown, and give deeper and less bright colours: yet there are cases in which they may be found the more useful ones. A solution highly charged with tin, that may be employed with advantage in certain cases, may be procured by decomposing in a retort, with a pretty strong heat, muriat of ammoniac, mixed with an equal weight of oxyd of tin; the residuum is to be dissolved, filtered, and evaporated till it crystallizes: thus crystals of a triple salt, composed of muriatic acid, ammoniac, and oxyd of tin, will be obtained. When this salt is used, a small portion of muriatic acid must be added to the solution, to prevent the precipitation of the oxyd of tin.

The solution of tin does not affect colours by the proportion of metal it contains merely. When sal ammoniac, nitre, or marine salt, has entered into the composition of the aqua regia, the liquor which is supernatant after the precipitation of the colouring particles is less acid, than when a mere mixture of nitric and muriatic acids is employed: in the former instance, therefore, the liquor has less action upon the stuff, and upon the colour, than in the latter.

Hence it follows, that when a solution of tin is to be used, with a substance, the colour of which is easily affected by acids, as madder or brasil-wood, we should choose a solution of tin that would retain little excess of acid, or use it only for the preparation of the stuff.

The art of dyeing does not possess another mordant capable of producing such advantageous effects as the solution of tin. I shall repeat the explanation I have given of its properties in the first section. 1. The oxyd of tin has a great disposition to quit its solvent to unite either with the stuff, or with the colouring particles. 2. It gives the colour a white basis not liable to alteration. 3. It produces no perceptible combustion in the colouring particles most disposed to change of hue from that cause, as those of sumach and galls.

The solution of tin acquires a gelatinous consistence more or less readily. When this happens, the dyers say, that the composition has turned. To avoid it, the preparation should be made but a little while before it is used. When the jelly is only beginning to form, the solution may be recovered by adding to it a solution of marine salt. This inconvenience arises from the tin's continuing to oxydate by means of the oxygen which it attracts from
the

the atmosphere, or receives from the nitric acid, whence it becomes insoluble in the acid, and falls down. Heat favours this effect; on which account the solution of tin does not keep so long in summer as in winter.

Constant observation teaches, that a less lively and agreeable colour is obtained by employing a solution of tin made with rapidity and the disengagement of much vapour, than by using a solution made slowly and without effervescence. The reason is, that in the former case, the tin acquires more oxygen, the superabundant part of which is more disposed to quit it, and to occasion a combustion of the colouring particles. On this account we should prefer fresh solutions, made with caution, to old ones, however carefully prepared.

Other solutions which may be of use in dyeing, are made with nitro-muriatic acid. De la Folie has proposed that of bismuth: and though he begins to dissolve the metal in nitric acid, it is a combination of it with the nitro-muriatic acid which is formed in the process, by means of the marine salt employed. The solution in nitric acid alone could not be made use of, because as soon as it is mixed with water, the metallic oxyd precipitates, so that it sepa-

rates, before it is able to unite with the colouring particles.

According to the description given by Mr. Dambournay of this process, which he has frequently employed¹, one part of bismuth is to be dissolved in four parts of nitric acid, this solution is then thrown into the bath, which contains tartar, and a solution of marine salt is poured in at the same time.

I have found, that, whether the solution of bismuth be made immediately in aqua regia, or the solution in nitric acid be mingled with a solution of marine salt and tartar, a considerable precipitate is always formed on mixing it with water, though less than when water is mixed with the simple solution in nitric acid. I have also remarked, that the precipitate formed by this solution with the decoctions of colouring substances had an unequal colour and speedily grew brown.

ARTICLE VI.

Of Tartar and some other Acids.

TARTAR is a salt deposited on the sides of casks, from which it is afterwards separated. It

¹ Recueil de procédés & d'expériences sur les Teintures solides,

is naturally mixed with impurities, deposited at the same time with it; and when it is separated from red wine, it retains a considerable portion of the colouring matter of the wine, whence it is distinguished by the name of red tartar.

Tartar is purified at Montpellier and at Venice, by different processes. At Montpellier, it is dissolved in water, and crystallized by refrigeration. The crystals are boiled in another vessel, with the addition of five or six pounds of white argillaceous earth of murviel to each quintal, and by evaporation is obtained the purified tartar, *cream of tartar*, *acidulous tartar of pot-ash*. The last of these names points out the nature of the salt, which consists of a peculiar acid combined in excess with pot-ash. All the acid may be separated from the alkali by means of lime, which has a greater attraction for it than the alkali has, and forms with it a salt scarcely soluble, whilst the alkali remains in the liquor. If, instead of lime, carbonate of lime be employed, the acidulous tartar will be deprived only of the excess of acid, when a truly neutral salt, *tartrate of pot-ash*, *vegetable salt*, may be obtained by crystallization.

The process employed at Venice, consists, according to the description of it given by

Mr. Desmarcets^m, in first, drying the tartar in iron pots: secondly, pounding it, and dissolving it in hot water; when, by refrigeration, crystals of a purer tartar are obtained: thirdly, in redissolving these crystals, and clarifying the solution with whites of eggs and ashes.

In the latter process, the alkali of the ashes must decompose a portion of the acidulous tartar; the calcareous earth must also effect a decomposition; and tartrate of pot-ash, or vegetable salt, must be produced at the end of the evaporation.

The acidulous tartrate of pot-ash, or cream of tartar, always retains a small portion of calcareous tartrate.

An ounce of water, at ten degrees of Reaumur ($54\frac{1}{2}$ Farh.) dissolves only four grains of this salt; but boiling water dissolves much more.

The acidulous tartar of pot-ash, which, throughout this work, I shall generally call by the simple name of tartar, is much used in dyeing. It is indispensably necessary to employ that which is purified, for delicate colours, and it is best to use it in all cases. In some processes red tartar has been recommended, on the supposition, that its colour would contribute to that intended to be given to the stuff; but on

^m Journal de Physique, 1771.

dissolving the tartar, its red particles separate, and should be considered as prejudicial impurities.

There is another salt which bears some analogy to tartar, and which would perhaps produce good effects in many cases; this is the *acidulous oxalate of pot-ash*, or salt of sorrel, extracted from the juice of sorrel, in Switzerland and in some parts of Germany. Scheele has shewn, that the acid of this salt is the same with that obtained from sugar, and several animal and vegetable substances, by treating them with nitric acid; but it is found combined in excess with alkali.

Pure oxalic acid forms an insoluble salt with calcareous earth, with which it has more affinity than any other acid, on which account it is proper for detecting the presence of calcareous earth in liquids, particularly in water. The acidulous oxalate of pot-ash may also be employed for this purpose; but the circumstance which may render it most useful, is its property of readily dissolving the oxyds of iron, and discharging the spots produced by them.

Vinegar, or the acetous acid, is too well known to require being noticed. Most vegetable substances afford a weak acid liquor, if left to ferment, and diluted with a sufficient quantity

quantity of water: but as it may be of importance, on many occasions, to procure an acid liquor of a certain strength readily and at a small expence, I shall relate an experiment, described by the illustrious Mr. de Morveau, on the acid obtained from wood by distillationⁿ, to which has been given the name of pyroligneous. Nothing more is necessary than to distil small bits of very dry beech wood, in an iron retort, in a reverberatory furnace, and to rectify the product by a second distillation, or at least to change the receiver, as soon as the oily part begins to rise, which is easily perceived, by its imparting a deeper colour to the acid. Fifty-five ounces of very dry chips of beech, afforded seventeen ounces of rectified acid.

CHAPTER II.

Of Alum, or Sulphat of Alumine.

ALUM is of such extensive use in the arts, and particularly in dyeing, the greater part of the phenomena of which are found to be connected with its properties, that it is an

ⁿ Encyclop. method. t. i. au mot *acide lignique*.

object of no small importance in commerce. The manner in which it is manufactured has therefore a claim to our attention, and I imagine it will not be useless, to speak of it at some length.

What we call alum, is a salt composed of sulphuric or vitriolic acid, and pure argil. To the latter has been given the name of alumine, from its property of forming the base of this salt. According to Mr. Kirwan, one hundred parts of alum contain about twenty-four of acid, eighteen of earth, and fifty-eight of water, which may be driven off by heat, without decomposing the saline combination.

This salt is found in some springs of mineral water: it effloresces on the surface of schists, in coal-mines, or on lava in the neighbourhood of volcanos, and on many rocks: but the greater part of the alum made use of, is procured from ores, or manufactured by artificially combining alumine with sulphuric acid.

Alum is mentioned in the works of the ancients, and that of Melos was particularly celebrated amongst the Greeks^a; but the learned Bergman^b imagines, that the alum of the an-

^a Voyage du jeune Anacharxis, t. iv.

^b Bergman *de confect. alum. opusc. vol. i.* This dissertation was written in 1767. Mr. Beckmann maintained the same opinion in the Gottingen memoirs, 1778.

cients was a native substance, that differed greatly from the salt which we call by that name; and that the species of alum of which Dioscorides speaks, were rather stalactites, which might indeed contain alum, but only in a small quantity, and mixed with other vitriolic substances. Nothing can be concluded from the description of Pliny, which is taken only from inaccurate relations.

Facitious alum was first known in the East: we cannot tell precisely when or where it began to be fabricated. One of the most ancient manufactories was that of Roche, a city of Syria, now called Edeffa; whence arose the appellation of roch alum, still, by an abuse of words, applied to alum in crystallized masses. In the fifteenth century, this art was carried into Italy, from which country it spread into Germany and the rest of Europe.

At the Solfatara, near Naples, is found an alum ore, under the form of a white earth. In this ore, alum is produced by the action of sulphureous acid, disengaged by the heat of the volcano, or argillaceous lava. This requires only to be dissolved and crystallized.

The purest of alum ores, is that of Tolfa, near Civita-Vecchia. It is composed, according to Mr. Monnet, who first analysed it, of forty
parts

parts of sulphur, fifty parts of clay, that is a mixture of argil and siliceous earth, a small quantity of carbonat of pot-ash, and a very small portion of iron. Bergman has also analysed it, and gives nearly the same proportions.

The other ores from which alum is obtained, are schists, more or less pyritous, and more or less bituminous. Those which are too pyritous, ought to be rejected, because they afford an alum containing much sulphat or vitriol of iron, from which they cannot easily be freed.

The operations by which alum is obtained from these ores, when it is not found ready formed in them, as at the Solfatara, have for their objects aluminatation, or the formation of the alum, the extraction of the alum, and its crystallization.

Most of the ores aluminatate, when exposed to the air and rain, without preparation; but those which contain too much bitumen, or too much sulphur, require to be roasted before they are exposed to the action of air and moisture; and this operation accelerates the formation of alum in all.

Aluminatation consists in the combination of oxygen, which, uniting with the sulphur, converts it into sulphuric acid, as Mr. Lavoisier has shewn: but it is in general, sulphat of iron
that

that is formed, which, acquiring an excess of oxyd by exposure to the air, is decomposed by the alumine. We know not any ore, except that of Tolfa, in which the acid appears to combine immediately with the alumine.

When the alum is formed, the ore must be lixiviated, and the lixivium must be evaporated, till it is in a proper state for affording crystals. These first crystals are washed, redissolved in a very small quantity of boiling water, and the solution poured into a kind of cask, the staves of which are afterwards loosened, that the mass of alum formed in it may be extracted.

The residuum of the crystallizations is mixed with a greater or less quantity of the solution of the ore, and evaporated till it is in a fit state for crystallization; and thus the workmen go on, adding the residua of the preceding crystallizations to fresh solutions of the ore.

There are here two essential circumstances to be observed: the first, that the solution obtained from the ore of alum, contains an excess of sulphuric acid, according to the observation of Bergman; the second, that sulphat of iron is always found in it, in greater or less quantity, and that this metallic salt remains chiefly in the residua of the crystallizations; for,
according

according to Mr. Monnet, it cannot form mixed crystals with the alum.

The excess of sulphuric acid tends to prevent the crystallization of the alum, so that, if it be not absorbed, a considerable quantity of the salt will be lost. It is with this view, that some add to the liquor, pot-ash; others, putrid urine, which contains ammoniac. The latter ought not to be employed, because, according to Bergman, the alum produced by it, has the effect of altering colours. That learned chemist proposed to saturate the excess of acid with argil, which would not only absorb the acid, but, at the same time increase the quantity of alum. Mr. Chaptal asserts, that this does not fulfil the intention: he says, that the alum itself dissolves an excess of argil, and lets it fall at the end of the evaporation; that then, there is obtained only a granulous precipitate, without any appearance of crystals; or, if we succeed in procuring a crystallization of the alum, without adding an alkali, the crystals have neither the same hardness, nor the same weight, as they have in common^c. Mr. Décroizille is of opinion, that the alkali contributes to the crystallization of the alum, not by subtracting the acid, but by the combination

^c Ann. de Chym. t. iii.

which

which takes place between the sulphat of pot-ash and sulphat of alumine; and he informs me, that he obtained this crystallization equally well, by employing sulphat of pot-ash instead of alkali.

Iron is sometimes found in a considerable quantity in alum, to which it is very prejudicial, particularly if it be used for lively and bright colours. This mixture might be avoided, by setting aside the residua, called mother waters, which are usually mixed with the liquors for crystallization. From these residua, which frequently contain also sulphat of magnesia and other saline substances, alum of an inferior quality might be procured for other uses mentioned by Bergman.

The alum of Tolfa, or roman alum, is generally preferred to every other kind. Its superiority consists, according to Bergman, in its containing much less iron: but by a careful crystallization, and not mixing with the solutions of the ore, the residue of the preceding crystallizations, other kinds of alum may be rendered even superior in quality. The roman alum contains a small portion of iron, in a peculiar state, to which is owing, according to the same chemist^d, that rosy tinge by which

^d Opusc. t. iii. de prod. volcan.

it is distinguished. An alum is prepared at Brunswick, to which the same tinge is imparted by means of a small portion of cobalt.

Mr. Décroizille is of opinion, that the roman alum differs from other kinds, and particularly from the English, in containing much less sulphat of pot-ash, and a larger portion of alumine. He has precipitated the alumine from english and roman alum with carbonat of soda, and found, that the latter required one third more than the former.

As good alum ores are scarce in France, endeavours have been made to supply their deficiency, by a direct combination of the sulphuric acid with alumine.

Common clay is a mixture of alumine, or that earth which constitutes the basis of alum, and siliceous earth, in very various proportions. It contains also more or less iron, and other kinds of earth. We should choose then the purest clays, that is, those which contain the least iron and calcareous earth.

Mr. Chaptal, having found, after many trials, that this process was too expensive to be pursued with advantage in the province of Languedoc, has sought after more simple and economical methods.

He forms into balls of five or six inches diameter a clay, which is carefully selected. These he calcines, breaks to pieces, and exposes to the vapour of sulphuric acid, at the moment of its formation, in a large chamber, constructed of wood coated with varnish, which he substitutes to the common ones of lead. The clay thus impregnated with sulphuric acid he leaves for some time under a shed; then lixiviates it, and proceeds to the crystallization. Far from making a secret of a manufacture which required many expensive trials, Mr. Chaptal has given a description of it, to be found in the memoirs of the academy for 1788, an abstract of which has been inserted in the third volume of the *Annales de Chymie*.

Mr. Décroizille, who has paid great attention to the manufacture of alum, assures me, that he is in possession of a method of combining the earth with sulphuric acid, much more speedy and æconomical than Mr. Chaptal's; and that he hopes France may soon have no further occasion to import alum, of which she at present procures a considerable quantity from foreign countries.

It appears, that in the choice of alum there are two principal objects of inquiry: First, Does it contain iron? To find this, the

infusion of galls may be employed, which will give a black tinge to a solution of the alum, if there be iron in it. Secondly, Does it contain much alkali in the form of sulphat? The method employed by Mr. Décroizille may be recurred to for the purpose of ascertaining this, taking true roman alum for the subject of comparison.

Thirty parts of water at the common temperature, are required to dissolve one of alum, according to Bergman, and of boiling water three parts are sufficient.

Alum is decomposed not only by alkalis, but even by the carbonats of lime and magnesia: yet it is to be observed, that even alkalis take away only a part of the acid, the precipitate retaining nearly half of it, and being a salt with a deficiency of acid, as Mr. Baumé has shewn.

If this precipitate be dissolved in an acid, as the nitric acid or muriatic, this acid seizes the excess of alumine, and re-establishes the proportions which constitute alum: so that by evaporation we obtain crystals, which appear different from those of alum, but, on a careful examination, their form appears referable to one of the varieties of the crystals of that salt. This I have ascertained on crystals procured

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from

from a solution of the precipitate of alum in nitric acid, which I requested Abbé Haüy to examine: I also satisfied myself, that it was the sulphuric acid which entered into the composition of those crystals. The alumine may be deprived of the acid which it retains when precipitated, by digesting it in a solution of fixed alkali, or of ammoniac: in this case no crystals will be obtained from its solution in the nitric or muriatic acid.

Lime and caustic alkalis, mixed with the solution of alum in certain proportions, determine that salt to assume a cubical form, which phenomenon was, I believe, first described by Mr. Sieffert^c, and has given occasion to many interesting observations from Mr. le Blanc^f; but the species of combination formed in these mixtures, and the proportions it admits, have not yet been ascertained. It appears, that the lime and alkali united with the alum,

^c Siefferts Versuch mit einheimischen Farbematerien, &c. 1775.

Mr. Sieffert quotes a dissertation on cubic alum, which he published in the Hamburg magazine. To obtain this cubic alum, he directs twelve parts of common alum to be mixed with one part of lime slacked in the air, to dissolve the mixture in boiling water, and to evaporate slowly.

^f Journ. de Physique, 1788.

facilitate the separation of the alumine, and consequently its combination with the substances submitted to the process of aluming. This process is employed with success in dyeing linen and cotton.

I have a few more remarks to add on the combination of the colouring particles with alumine, and of alumine with the alkalis.

It would be superfluous to repeat here the manner in which alum acts in the processes of dyeing; as in the theory I have laid down, I have particularly called the reader's attention to that subject.

The name of lake is sometimes given to the combination of colouring matter with alumine, obtained by mixing alum with a solution of colouring matter, and adding a proper quantity of alkali to effect or complete the precipitation. The term lake, however, has several significations: it originated from an extract of lac, a colouring substance, of which I shall treat in the second volume: it was afterwards applied to dry pastels coloured with lac, for the use of painters; and at length to dry pastels and powders of various colours, and different natures.

Alumine dissolves pretty copiously in pure or caustic alkalis, especially if aided by calci-

nation. Macquer paid great attention to this solution, and considered it as a very advantageous mordant, particularly for dyeing cotton with madder^z. I have repeated and varied his experiments, but I confess, that I have been far from succeeding in the degree he professes to have done: it even appeared to me, that the colouring particles have too great an attraction for the alkali to separate from it, and fix in sufficient quantity on the stuffs, from which the alkali itself has the property of taking them. On this subject, however, I suspend my opinion, because I find Mr. Hauffman also, whose authority is of great weight, considers the combination of alumine and pot-ash, which he styles alumine of pot-ash, as well calculated for the purpose of a mordant^b.

^z In a memoir not published, which he read at a meeting of the academy.

^b Lettre de M. Hauffman. Ann. de Chym. tom. vii.

C H A P. III.

Of the Sulphat of Iron, or Martial Vitriol.

TH E sulphat or *vitriol of iron, martial vitriol, green copperas*, is crystallized in rhombs, of a beautiful green colour, transparent when recently crystallized. In a hundred parts, it contains twenty-four of sulphuric acid, twenty-four of iron, and fifty-two of water.

The sulphat of iron may be made directly with iron, and sulphuric acid diluted with a certain quantity of water. This solution exhibits phenomena far from uninteresting to the chemist, but which it is not our business to consider at present. The sulphat of iron formed in this manner, bears a price which does not permit it to be employed in the arts, and nature furnishes us with means of obtaining it at a much cheaper rate.

Native sulphat of iron is found in coal-mines, in the cavities of pyritous ores, and in schists: but the greater part of what is consumed, is obtained from martial pyrites.

Pyrites are stones consisting of oxyds of iron, sulphur, argil, siliceous earth, and sometimes calcareous earth, in various proportions. The formation of the sulphat of iron in these stones is effected by exposing them a considerable time to the action of the air and moisture, or by roasting them in the open air, and leaving them afterwards exposed to its action. It is even necessary sometimes to repeat this operation. The sulphat, when formed, is obtained by lixiviation and evaporation.

Sulphat of iron is also prepared with mineral waters, which hold copper in solution. The copper is precipitated by means of iron, and the solution, which still retains a small portion of copper, is made to crystallize.

The sulphat of iron of Goslar, commonly contains a little zinc; that of Hungary, and that of Saxony, a little copper^a. The sulphats of England and of France are more pure. These, however, sometimes contain alum; particularly the latter.

Sulphat of iron might be made, free from copper or alum, if care were taken to keep pieces of iron in the evaporating vessel, as

^a Kirwan's Mineralogy.

Mr. Monnet advises ^b; since iron has the property of precipitating both copper and the base of alum. It appears, that the superiority of the english vitriol is owing to this precaution, which is observed also in the two manufactories near Alais ^c. There is only zinc which will not be precipitated in this way; but that is seldom found in sulphats of iron, and never in any quantity.

The copper contained in many sorts of sulphat of iron, appears not to be prejudicial to the black dyes, for which this metallic salt is chiefly employed. If, however, it be required to free them from it, it may be done by keeping plates of iron for twenty-four hours immersed in a cold solution of the salt, when the whole of the copper will be precipitated on these plates. Crystallization is incapable of producing the effect, because, as Mr. Monnet observes, the sulphats of iron and of copper form a mixed salt, and will not separate.

Alum is probably more detrimental to black than copper; for when a black stuff is boiled with that salt, it discharges the colour by dissolving it. It is apparently on this account,

^b *Traité de la Vitriolisation.*

^c *Chaptal's Elements of Chemistry, vol. ii.*

that the english vitriol is so much esteemed.

Sulphat of iron may be freed from alum also, by keeping it some time in digestion with iron filings: but this decomposition is more difficult and less complete, than that of the sulphat of copper.

It is only from want of care in the crystallization however, that the sulphat of iron retains alum: for, as observed by Mr. Monnet, these two salts cannot combine into mixed crystals, so that they may be separated by a careful crystallization.

When sulphat of iron is kept long exposed to the air, it tarnishes and becomes yellowish: its solution grows turbid by boiling, a part of the iron is precipitated in the form of a yellow powder, and it loses the property of forming crystals. These phenomena are owing to the iron attracting oxygen, or the base of pure air, from the atmosphere, with which when it is saturated to a certain point, it cannot be kept in solution but by an excess of acid. Hence it continues to be precipitated, till what remains is capable of being held in solution by the acid which is found in due proportion. To avoid this kind of decomposition, the sulphat of iron should not be dissolved

dissolved till the moment it is wanted, and it should be dissolved with the least possible heat. I have remarked, that a solution made with a low degree of heat, kept much longer exposed to the air without growing turbid, or depositing a sediment, than a solution made by boiling, and afterwards filtered.

Sulphat of iron is of great use in dyeing, particularly for black, gray, and other hues, which are darkened by its means. I have shewn, in the first section, how it acts by combining with the astringent principle and the colouring particles.

Solutions of iron in the acetous and some other vegetable acids, are also used in dyeing: but these preparations are made in the places where they are used, and their description will be found with that of the processes, of which they make a part.

All the solutions of iron differ greatly in the state in which the metal exists in them, and in the property of attracting more or less oxygen from the air.

The solution in nitric acid, according to the observation of Mr. Hauffman^d, shews no marks of absorbing vital air, even when agi-

^d Journ. de Physique, 1787.

tated in contact with it ; but it retains a great excess of acid.

The solution in acetous acid is at first of a pale green ; by absorbing vital air it grows more and more yellowish ; and at length acquires a very deep reddish yellow colour. It takes a great proportion of iron, and absorbs oxygen without forming a sediment.

The solution in sulphuric acid attracts oxygen more slowly than the preceding one, forms a deposit of oxyd proportionate to the quantity of that principle, and thence acquires a gradually increasing excess of acid.

The muriatic acid dissolves oxyd of iron in whatever state it finds it : but if it contain much oxygen, a part of the acid is disengaged in the form of oxygenated muriatic acid, as Mr. Fourcroy has observed.

These properties of the solutions of iron, may serve to explain the differences they exhibit, when employed in the arts.

C H A P. IV.

Of the Sulphat of Copper, or Blue Vitriol.

THE fulphat of copper, *blue vitriol*, *cyprus vitriol*, *blue copperas*, is a salt composed of oxyd of copper and sulphuric or vitriolic acid. This salt readily forms blue crystals of a rhomboidal form. The quintal contains thirty pounds of acid, forty-three of water, and twenty-seven of copper. At the temperature of twelve degrees of Reaumur (59 Farh.) it requires nearly four parts of water to dissolve it.

Sulphat of copper is of no great use in the arts, whence little attention has been paid to the different processes by which it may be prepared.

In making the fulphat of copper for commerce, two methods are employed. The first consists in calcining copper pyrites, or the mat which results from the fusion of copper ore, and which is a compound of copper and sulphur, and leaving the product of the calcination to effloresce. By this means the copper is oxydated, and the sulphur converted
into

into sulphuric acid. The salt formed is then extracted and crystallized. The second method is to calcine an artificial mixture of sulphur and copper, to leave it in like manner to effloresce, to lixivate the salt, and crystallize it.

There are some waters that contain copper combined with the sulphuric acid, which might be employed when we want to use sulphat of copper.

Lime and the alkalis produce, with the sulphat of copper, a greenish blue precipitate, which soon becomes green in the air. Ammoniac produces a beautiful blue precipitate, which it quickly redissolves, and which also becomes green in the air. These differences of colour depend on the proportions of oxygen combined with the copper: if it be in small quantity, the oxyd is blue; if in a larger, it is green: whence the blue oxyd becomes green in the air, by combining with the oxygen which it attracts from the atmosphere.

Oxyd of copper easily combines with most kinds of colouring particles, by which it is precipitated from acids. It frequently imparts to them a pleasing colour: but as its own colour, which influences that of the combination, is easily changed by the air, the colours

hours resulting from its mixture are variable, and of little duration, so that there are few occasions on which it can be employed with advantage.

It has been remarked, that the sulphat of copper attacks cloths more than that of iron^e. This effect is partly owing to its possessing a much greater quantity of active acid than the latter: for, according to Mr. Kirwan's calculation, one hundred parts of sulphat of iron contain twenty parts of sulphuric acid, and a hundred parts of sulphat of copper contain thirty. This acid is set free when the oxyd combines with the colouring particles, and exerts its action on the cloth, or rather on the combination of the cloth with the colouring particles. But what more especially augments on one hand the quantity of acid set free, and consequently its action on the cloth, and on the other, the influence of the oxyd of copper on the qualities of the colour, is, that this oxyd enters in a large proportion into the combination which it forms with the colouring particles. I have precipitated an equal quantity of decoction of fustic (*bois jaune*) with sulphat of copper, and with sulphat of iron,

^e *Instruction sur l'art de la Teinture*: by Mr. Poerner.

and found the precipitate produced by the former, much more considerable than that produced by the latter: consequently there was more sulphat of copper decomposed by the same quantity of colouring matter, than sulphat of iron. The quantity of acid set free is more considerable therefore, on two accounts.

A proof, that the action on the cloth is not owing principally to the oxyd of copper, is, that the same objection is not made to verdegriis as to blue vitriol.

C H A P. V.

Of Sulphat of Zinc, or White Vitriol.

THE sulphat of zinc, *vitriol of zinc*, *white vitriol*, *white copperas*, is composed of sulphuric acid and oxyd, or calx of zinc. A little more than twice its weight of water is required to dissolve it at a temperature of twelve degrees of Reaumur (59 Farh.) and by evaporation we obtain crystals in the form

form of a tetrahedral prism, terminated by a quadrilateral pyramid. According to Mr. Kirwan, a hundred parts of fulphat of zinc contain twenty-two of acid, twenty of zinc, and fifty-eight of water.

The greater part of the fulphat of zinc met with in commerce, is prepared at Goslar, where, after having roasted and distilled the ore which contains the zinc, the residuum is thrown red-hot into water, lixiviated, and the liquor evaporated, by which means this metallic salt is obtained.

The fulphat of zinc of the shops always contains iron, and when a solution of it is left exposed to the air, or made to boil, it grows turbid, and a portion of the iron precipitates; but the greater part always remains, and cannot be entirely precipitated but by boiling the solution with filings of zinc: even by this process it is difficult to separate the whole of the iron.

Hitherto little use has been made of this metallic salt in dyeing. When it has been employed, it has been found to render the colour deeper; which effect is owing, in a great measure, to the iron which it always contains. I have made fulphat of zinc by dissolving zinc in sulphuric acid: some of this solution I have

poured into infusions of sumach, galls, madder, and cochineal, and compared the effects it produced with those of a solution of common fulphat of zinc, which had been long made, and had deposited all the iron that exposure to the air would throw down. The latter rendered the colours much deeper than the former. The deposit produced by the pure fulphat with the infusion of sumach was a violet lilac; with the infusion of galls, a little deeper; with that of madder, bright purple; with that of cochineal, first red, afterwards a beautiful purple. In general the precipitates produced by the fulphat of zinc grow a little darker with time; which indicates, that the oxyd of zinc produces a slight combustion of the colouring matter: it appears, moreover, to combine with it but in small proportion. Hence we see the reason why it renders colours darker than the oxyd of tin, though they are equally white.

C H A P. VI.

Of Verdegris, and Acetite of Copper:

FORMERLY verdegris was prepared only at Montpellier, and in its neighbourhood. The process followed there consisted in fermenting the stalks of grapes with wine-lees, stratifying plates of copper with these stalks, taking them out after some time, setting them up edgewise in a corner of the cellar, where they were again sprinkled with wine-lees, and scraping off the verdegris which swells up from the last operation. The same process was repeated on the plates of copper, after having removed the verdegris.

At Grenoble they use vinegar ready made, with which they sprinkle the plates of copper. The verdegris prepared in these two ways differs in some of its properties.

The copper is reduced to an oxyd from the same causes as lead is in the making of white lead, that is, from the concurrent action of the atmospheric air, and the acetous acid, which is employed, or which forms in the grape-stalks: but as vessels of copper are much used, it may not be improper to consider the manner in

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which

which acids act on that metal somewhat at length.

For copper to dissolve in acids, it is necessary, as with other metals, that it be combined with oxygen, or reduced to a calx or oxyd. It is requisite, therefore, that it attract oxygen from the atmosphere, or that the acids furnish it, or indeed that it decompose the water. The last case requires circumstances which do not occur in the processes of dyeing.

Vegetable acids cannot impart oxygen to copper: but the action they exert on it favours its combination with oxygen so much, that it readily attracts the atmospheric air, by which it is reduced to an oxyd, and becomes soluble in the acid liquor. But that the copper may be capable of attracting the oxygen of the atmosphere, it is necessary, that the liquor be cold: hence vegetable acids whilst hot do not attack copper, and the same thing holds with respect to oils, and other substances which act on that metal, unless a portion of copper be previously oxydated, in which case it readily dissolves, whatever be the temperature of the liquor. From this we see the necessity of never suffering liquids capable of attacking copper to grow cold in vessels of that metal, and of taking care to keep them always extremely
clean,

clean, that no oxyd may be found formed on their surface.

The nitric acid, and nitro-muriatic acid, or aqua regia, have the property, though diluted with water, of imparting oxygen to copper, and of dissolving it, especially when the liquor is in a state of ebullition. Thus it is impossible to prevent a portion of the metal from being dissolved in baths into which is put solution of tin, for instance, unless the copper be carefully tinned. One circumstance, however, tends to diminish this effect, the action of the nitric acid being exerted on the vegetable substances, and still more on the animal substances, that are in the bath with it.

The copper in verdegriis, then, is reduced to an oxyd, and combined with a portion of acetous acid more or less considerable. When the oxyd of copper is completely saturated with this acid it is wholly soluble in water, and by evaporation forms blue rhomboidal crystals, which, fixing on little sticks, produce those groups known by the name of *crystallized verdegriis*, *crystals of Venus* (distilled verdegriis). The difference between this salt and verdegriis is, that in the former, the oxyd of copper is completely saturated with acetous acid, or it is the acetite of copper; and that in the

verdegris there is only a portion of the oxyd of copper in the state of acetite. This saline portion may be separated by solution in water, the oxyd of copper, which is insoluble in water, remaining undissolved: but this may easily be dissolved in acetous acid, and thus reduced to the same saline state^a. Sometimes verdegris contains very little acetite; at others, on the contrary, it contains scarcely a fourth of its weight of uncombined oxyd of copper. To this is owing the difference which distinguishes the verdegris of Grenoble from that of Montpellier: the former containing much more acetite of copper; the latter, of oxyd of copper uncombined.

These observations may be useful to any one who should attempt to make verdegris, or distilled verdegris, for himself, which might be done in different ways, according to circumstances; and for judging of the qualities of verdegris, which will be more or less fit for any particular use, according to its nature. Then, if it be necessary, that the verdegris should be dissolved, the greater part of what was used would be waste if it contained but little acetite. In this case, the uncombined oxyd might be dissolved in vinegar, and then

^a Mem de l'acad. 1, 82.

the whole rendered fit for the purpose required. In other circumstances, it is the oxyd that is useful; when we should choose verdegris that contains little acetite, or even dissolve the acetite, and reserve it for other occasions.

The verdegris used in dyeing black acts principally, and perhaps solely, by its uncombined oxyd. This oxyd serves to precipitate the iron combined with the astringent principle, by combining with the sulphuric acid; which will explain the observations of Mr. Clegg, that I am going to relate^b.

Mr. Clegg, endeavouring to discover some cheaper ingredient, that might be substituted instead of verdegris for dyeing black, observed, that the copper of the verdegris precipitated the iron of sulphat of iron, held in solution with astringent substances, in the state of oxyd. But I have remarked, that the iron was combined with the astringent principle, when precipitated by the oxyd of copper, and even that the oxyd of iron cannot be precipitated by the oxyd of copper but on account of the double affinity which results from the

^b Transactions of the society, instituted at London, for the encouragement of arts, manufactures, and commerce, vol. i. pag. 181.

action of the astringent principle. Considering the verdegris as a precipitant of iron, Mr. Clegg sought to substitute for it other substances calculated to precipitate iron from its solvents. He first tried alkalis, which appeared to succeed in a small way, but would not answer on a large scale: in fact, alkalis do not precipitate the combination of iron and the astringent principle, but form with it a supra-compound, and give it a reddish tinge. He afterwards ascertained, by repeated experiments, that the purpose of verdegris might be fully answered by a mixture of sulphat of copper and pot-ash. The sulphat of copper he directs to be dissolved, and a solution of pot-ash to be added till the blue colour disappears, that is to say, till the whole of the copper is precipitated. Nearly equal weights of sulphat of copper and of the alkali are requisite for this purpose: and Mr. Clegg assures us, that these will supply the place of a quantity of verdegris equal to the weight of both, particularly in dyeing hats; in which much verdegris is employed.

The advantages of this process depend on the comparative prices of sulphat of copper, of pot-ash, and of verdegris. Instead of the

fulphat, we may use the solution of copper in nitric acid made in the operation of parting.

C H A P. VII.

Of the Acetite of Lead, or Salt of Saturn.

THE acetite of lead, or salt of saturn, is a combination of lead, reduced to an oxyd or calx, with acetous acid or vinegar. It is generally crystallized in fine confused needles; if, however, it be crystallized by a slow evaporation, white crystals in flat parallelipedons, terminated by two surfaces inclining in opposite directions, will be obtained.

This salt has, with a slight astringency, a saccharine taste, from which it has acquired the improper appellation of sugar of lead. It is in some degree decomposed by water, and forms with it a milky liquor, that deposits a white powder, partly owing to the oxyd of lead which has forsaken the acid: but this deposition may be prevented by the addition of a certain quantity of acetous acid; a process that may be useful when this salt is employed

ployed in dyeing. Beside this deposit, which takes place even in distilled water, another occurs in waters containing sulphat, which is owing to a combination of the oxyd of lead with the sulphuric acid, and is proportional to the quantity of that acid. The salt resulting from the muriatic acid is sufficiently soluble not always to form a deposit.

The acetous acid does not attack lead in its metallic state, unless in contact with the air: but if the air touch its surface, the lead gradually becomes oxydated, by means of the oxygen it attracts, and is thus rendered soluble in the acid.* As this manner of preparing acetite of lead, however, would be disadvantageous, both because it would require much time, and because a great part of the acetous acid would evaporate, recourse is had to other processes.

White lead is an oxyd of lead which appears to be combined with a small portion of acetous acid. To form it, lead in sheets is suspended over vinegar, in earthen vessels, which are buried in dung, that the heat may keep up the evaporation of the vinegar, which, in exhaling, reduces the lead to an oxyd by the assistance of the air. This oxyd, which is powdered with great care, forms white lead: but

but a part of it, falling into the vinegar, dissolves in it, and forms acetite of lead, which requires only to be evaporated, and purified by a second crystallization.

Acetite of lead is prepared for the most part with distilled vinegar, obtained from beer or wine, and white lead, which, as has been said, is an oxyd of lead reduced to a very subtil powder, and consequently in the most favourable state for solution. Descriptions of the processes by which it is prepared in the large way may be seen in the *Art du Distillateur* of Mr. de Machi, and more particularly in the *Dictionnaire de Chymie* of Mr. de Morveau, under the article *Acétite de Plomb*.

If a person find himself in want of acetite of lead, he may easily make it, by dissolving an oxyd of lead in distilled vinegar, and evaporating the solution to the proper point for crystallization. Various oxyds of lead may be employed for this purpose. White lead dissolves more easily than any other, except ceruse but this should be rejected, because it is a mixture of white lead and chalk. Litharge, or the semi-vitrified oxyd of lead, may be taken instead of white lead; but minium dissolves with more difficulty.

In many cases, it would be sufficient, to dissolve the oxyd of lead in white wine vinegar, the extractive part of which, that constitutes its principal difference from distilled vinegar, would not injure colours. Neither would the excess of acid which this solution might retain be detrimental, and it might prevent the formation of the precipitate that takes place when acetite of lead is dissolved in water. As the acetite of lead is of some price, this process might be employed with advantage where much is used.

The acetite of lead forms, in general, a copious precipitate with solutions of the colouring particles.

It deepens colours, and renders them more permanent, but less bright. The greatest use made of it is for the composition of the principal mordant employed for printed linens, in which it serves, as has been said, to form a combination of the base of alum with acetic acid.

C H A P. VIII.

Of Fixed Alkalis.

IN chemistry two alkalis are distinguished: fixed alkali, and volatile alkali, or ammoniac. The former resists the action of fire; the latter evaporates at every degree of temperature to which our atmosphere is liable. Each has a powerful action on the colouring particles: but as the volatile alkali is not used in dyeing, or, at least, not in an uncompounded state, fixed alkali only will be considered here.

Fixed alkali is divided into two kinds: vegetable fixed alkali, or pot-ash, and mineral alkali, or soda.

ARTICLE I.

Of Vegetable fixed Alkali, or Pot-Ash.

THIS alkali is extracted from the ashes of various vegetable substances, whence it has obtained the name of vegetable alkali: and as it is more or less pure, more or less caustic, according to the substance from which it is
procured,

procured, and the circumstances attending its preparation, many varieties are made of it in commerce, to which have been given different names, indispensably necessary to be distinguished. First, however, we must consider alkali, independently of the mixtures by which its properties are modified.

Vegetable alkali may be pure, and free from all combination, or it may be combined with carbonic acid. In the former state it is *pot-ash*, the *pure pot-ash* of chemists, *caustic vegetable fixed alkali*: in the latter, it is *carbonat of pot-ash*, *effervescent vegetable fixed alkali*.

Pure or caustic pot-ash has a very acrid lixivial taste. It attracts the humidity of the air so powerfully, that it cannot be made to crystallize but by peculiar processes. In this state it combines with oils to form soap. But the purity of alkali is never absolute; it always retains earths in solution; unless alcohol or spirit of wine, be employed to purify it^a. Hence when we saturate it with an acid, a sediment is formed, which sometimes assumes the appearance of a jelly: this sediment is produced by the earth, which separates.

The carbonat of pot-ash is the salt just mentioned saturated with carbonic acid. In this

^a Mem. de l'acad. 1782.

state it no longer holds earth in solution, and it produces an effervescence with acids, owing to the carbonic acid, which escapes, and assumes the form of gas. This salt has a flavour analogous to that of pure alkali, but much weaker, and without causticity. It ought to be considered as a true neutral salt, and is reducible into crystals, like most other salts of this species. Lime mixed with it seizes its carbonic acid, and precipitates, thus rendering it caustic. It likewise parts with its carbonic acid when urged by a strong heat.

The alkali obtained from ashes, or found in commerce under different denominations, is a compound of pure alkali and carbonat of potash. The proportion of these varies, not only in salts sold under different names, but even in those which are prepared in the same way. A difference in the degree of heat employed is sufficient to produce a difference in causticity; and they are besides mixed with greater or less quantities of earth, and heterogeneous salts.

The most simple method of separating alkali from earths, and heterogeneous salts, is to leave it exposed to the air in a moist place: the alkali attracts the humidity of the air; and the earth, with the greatest part of the hetero-

gencous salts, forms a sediment, from which is to be poured off the liquor, improperly called oil of tartar by deliquescence. The part combined with carbonic acid, which, if alone, would have formed crystals, dissolves by means of the caustic part: but it is to be observed, that, if the solution be long left exposed to the air, it gradually attracts the carbonic acid which always exists in the atmosphere, and at length crystallizes, as Bohn and Montet long ago remarked. If a more speedy method of purifying the alkali be required, nothing more is necessary than to mix it well with an equal weight of cold water, and filter the liquor, or let it settle, and decant it when clear. An equal quantity of water may be poured on the residuum; but the alkali thence obtained will be much less fine than the former.

Salt of tartar is an alkali obtained from the combustion of tartar, wrapped up in cones of paper. The residuum of this combustion is dissolved in water, the solution is concentrated on the fire, the heterogeneous salts are separated as they precipitate, and by desiccation is obtained the salt of tartar, the purest alkali to be met with in commerce, but at the same time the dearest. The alkali of salt of tartar has little causticity.

Cendres gravelées abound in alkali, but are less pure than salt of tartar. They are produced from the combustion of wine-lees and the ashes of vine-twigs.

The pot-ash of commerce is the result of the combustion of wood, burnt for that purpose in some of the northern countries where forests abound, chiefly in Russia and Sweden. According to Linnæus, birch or alder is burnt with a slow fire; the ashes are made into a kind of paste with water; billets of fir or pine are laid in a row, and covered with this paste; on this row another, covered in like manner with the paste, is laid transversely; and this is repeated, till the pile rises to a considerable height: this pile is then set on fire, and when the ashes begin to run, it is overturned, and the melted ashes are beaten with flexible rods. By this operation they are mixed with the logs, and become as hard as stone.

It appears from this account, that pot-ash must contain much earth; but it seems too, that lime is sometimes mixed with it. Dr. Home found it principally in a kind of pot-ash, called *cashub ashes*, which are much used by the bleachers in Flanders and Artois^b.

^b Essay on Bleaching.

An excellent judge, Mr. Chaptal, thinks, that a saving might be made by the establishment of a manufacture of pot-ash in some of the forests in France. He says, he has found from nice calculations, that a pot-ash which he caused to be manufactured in some of the forests of Languedoc, came not to more than half the price given for that which is brought us from the North^c. He observed, that the ashes of hard woods generally contained the most; and ashes of box afforded him twelve or fourteen pounds in the hundred. According to Mr. Sage, a hundred pounds of oak give only half a pound of ashes^d.

The action of ashes in ley is owing to the alkali they contain; hence float-wood, having been deprived by the water of the saline and extractive matter, from which the alkali ought to be disengaged by combustion, affords inactive ashes.

It is easy to see, that the pot-ash of commerce, the vegetable alkali chiefly used in the arts, must differ considerably, according to the mixtures naturally found in it, or added to it, and the circumstances attending its making. Now, to ascertain the real quantity of alkali

^c Elements of Chemistry, vol. i.

^d Journal de Physique, 1789.

contained in it, would be of no small advantage. By the taste, we should easily be deceived; for that pot-ash which contained alkali in a more caustic state, would appear far more acrid than that in which the alkali was combined with a greater quantity of carbonic acid. Trials on leys, or on colouring matter, might prove fallacious, for the same reason. A certain method of estimating it would be, to dissolve a given weight in water, to filter the liquor, and to compare the quantity of acid it would require to saturate it, and render it incapable of turning green the syrup of violets, infusion of radishes, or any other vegetable colour calculated for such a test, with the quantity necessary to produce the same effect on a known weight of pure alkali.

Pot-ash is of very extensive use in dyeing: in general it facilitates the solution of the colouring matter, and deepens its colour.

Some direct the use of salt of tartar, or *cendres gravelées*, in certain processes: but pot-ash may be substituted instead of them in all cases, if care be taken to purify it as I have directed; unless, indeed, an alkali containing much carbonic acid be required; and even this quality may be given to the solution of pot-ash, by leaving it some time exposed to the air. As

these alkalis differ greatly in price, this merits some attention.

As fixed alkali has a powerful action on substances of an animal nature, and dissolves them when it is in a caustic state, great attention should be paid to the proportions of this salt employed in processes to which these substances are subjected, and to the degree of causticity it possesses.

ARTICLE II.

Of Mineral Alkali, or Soda.

THE epithet mineral has been affixed to this alkali because it is frequently found in the bowels of the earth, on its surface, or in subterraneous cavities. Thus in Egypt, where it is called natron, it is obtained from two lakes, which grow dry in summer. It is also found in several parts of Barbary, in Syria, Persia, the East-Indies, and China, and even in our climates. The greater part of what is used, however, is obtained from the combustion of plants growing on the sea-side, particularly from the kali, or soda; whence the generic name of soda has been given it by most modern chemists.

The

The natron contains sea-salt and sulphat of soda, or Glauber's salt, in different proportions.

Mineral alkali exhibits the general characters described in speaking of pot-ash : but it differs from it principally, first, in affording different neutral salts with the acids ; secondly, in being always saturated with carbonic acid in its natural state, and affording crystals, which, far from attracting the humidity of the air, yield to it their water of crystallization, and thus effloresce, assuming the appearance of flour. The soda of commerce contains a greater or less quantity of earth, sea-salt, sulphat of soda, or Glauber's salt, coal, and sulphuret of alkali or liver of sulphur. That which is of a good quality, does not yield above five or six ounces of salt of soda (per pound) which may be separated by solution and crystallization. The best is that obtained from barilla^c, on the coast of Spain, and known by the name of alicant soda. Mr. Chaptal is convinced, that this plant might be cultivated with the greatest success on the coasts of the Mediterranean.

A plant, known by the name of *salicor*, which affords soda of a good quality, is cultivated on

^c See a description of this plant, by Jussieu, in the memoirs of the French Academy for 1727.

the borders of ponds in Languedoc and Provence.

A kind of soda, known by the name of kelp, *cendre de varech*, is prepared on several of our coasts. It contains but little salt of soda, and its saline parts is sometimes wholly sea-salt. In general, plants that grow without culture, produce soda of an inferior quality.

The method above directed for trying the quality of pot-ash, is equally applicable for determining that of soda.

To free the mineral alkali from heterogeneous salts, it should be dissolved in water, and the different salts separated as they precipitate or crystallize: the crystals of salt of soda are the last that form.

When salt of soda is used, it is essential to attend to its state; for when it is in crystals, it contains more than half its weight of water of crystallization, so that when it has fallen into efflorescence, one part will produce as great effect as two of the crystals.

Salt of soda is a carbonat of soda, a combination of carbonic acid with pure soda. Lime acts on this salt in the same manner as on the carbonat of pot-ash; that is, it takes from it its carbonic acid, and renders it caustic: in this
state

state it is pure soda, or simply the *soda* of chemists, the *soap-boilers ley*.

In some places, the appellation of *aqua-fortis*, or *soap-boilers aqua-fortis*, is given to a solution of caustic or pure soda[†]. Such a denomination may easily occasion mistakes, and make this alkaline solution be confounded with nitric acid, or common *aqua-fortis*. Hellot informs us, that he was thus deceived with respect to the manner of preparing an indigo-vat, for which directions had been given him.

Lately, several processes have been discovered for extracting the soda from sea-salt or muriat of soda, of which it is the base. Of many the secret has not been disclosed. If these processes be not too expensive for extracting the soda with profit, they ought to be considered as very beneficial, as this salt is of extensive use in several of the arts, and we are obliged to procure it from foreign countries.

[†] Procès-verbal des Opérations de Teinture faite à Yvetot, par François Gonin.

C H A P. IX.

Of Soap.

SOAP is a combination of oil with alkali ; but that this combination may take place, it is necessary that the alkali should be pure, that is, free from carbonic acid. Vegetable alkali, or pot-ash, and mineral alkali, or soda, are both capable of forming soap : yet the latter is preferred, because the soap made with pot-ash has not an equal degree of solidity.

To make the soap of commerce, we begin with rendering the soda caustic. For this purpose, one part of good alicant soda and two of quick lime, are boiled in a sufficient quantity of water ; the liquor is filtered, and evaporated to such a degree, that a phial which would contain only eight ounces of pure water, will hold eleven ounces of this liquor, called *soap-boilers ley*. One part of this ley, and two of oil, boiled together, till, on taking up some of the mixture with a spatula, it does not adhere, and speedily coagulates, form soap.

In almost all manufactories the ley is prepared cold, by filtering water through a mixture

ture of equal bulks of powdered alicant soda and quick lime. This lye is then mixed with oil in the boilers, and their combination is promoted by the action of heat. The ley that passed last through the filter, and which is the weakest, is put into the boiler first, and stronger ley is added gradually, till the end of the operation.

To make mottled soap, soda in its native state, sulphat of copper, or blue vitriol, cinabar, &c. are employed, according to the colour sought.

A soft soap also is prepared^a by boiling a ley made of soda, pot-ash, or even common wood ashes, with the cake left after pressing out the oil of olives, nuts, or rape, with fats, with fish oils, &c. which make black or green soap. Mr. de Bullion has proposed to make soaps with animal fats^b: I have been assured, that a learned chemist has a manufacture of this kind of soap in England. In America, soap is made with green wax.

All the acids, even the carbonic acid, decompose soap, and separate the oil by combining with the alkali. Salts, with earthy or metallic bases, have the same property; but they effect

^a Chaptal's Elements of Chemistry, vol. ii.

^b Journ. de Physique.

it by a double decomposition: whilst the acid unites with the alkali, the oil combines with the earth or metallic oxyd, from which result the earthy and metallic soaps I have elsewhere described^c, that probably might be of some utility in the arts.

The principal use of soap in dyeing, is for whitening the silk. For this purpose, a white, hard soap, prepared with olive oil, should be chosen: whence it is, that the best soap is made only in places where this oil abounds, as Portugal, Spain, or Marseilles.

The ancients used a plant, called by Pliny, *radicula*^d, supposed to be our soap-wort, for the purpose of cleansing woollens: for bleaching linen, they employed a plant, that appears to be a sort of spurge.

C H A P. X.

Of Sulphur.

SULPHUR is found combined in different minerals; but what is made use of, is chiefly extracted from volcanic earths, particularly from the Solfatara near Mount Vesuvius,

^c Mémoires de l'Académie, 1780.

^d Plin. lib. xix. cap. iii.

where it is purified, and cast into moulds, that give it the form under which it is called *roll brimstone*.

When sulphur is burnt slowly, it is reduced into a volatile acid, of a very penetrating smell, and called sulphureous acid. If this acid be left in contact with a sufficient quantity of atmospheric air in a close vessel, all the pure part of the air, that is, its oxygen, is gradually absorbed, and the sulphureous acid is changed into sulphuric acid; so that the difference between the two acids depends on the proportion of oxygen, and the state in which the oxygen exists in them.

In the sulphuric acid the oxygen has lost the caloric to which it owed its expansive state: in the sulphureous acid it has retained such a quantity, that the combination it has just formed, is volatile, and loses its elastic state with difficulty. Thus in the former, the oxygen is much more concentrated, and much better combined: in the latter, its affinity is divided between the caloric which it has retained and the sulphur. For this beautiful theory of the nature and formation of acids, we are indebted to Mr. Lavoisier.

Sulphuric acid acts on colouring matters like other acids: but the sulphureous acid, particularly

particularly when in an aeriform state, destroys several colours.

It is a property of sulphureous gas to discharge the colour of the colouring matter with which it combines : but the colour in general is restored on saturating it with an alkali. The colour thus restored, however, vanishes in time, because a combustion takes place similar to that produced by nitric acid, or oxygenated muriatic acid, which is owing to the weak adhesion of the oxygen in the sulphureous acid.

Sulphuration, or exposure to the vapour of sulphur, is employed to give woollens or silk designed for white stuffs, the greatest possible degree of whiteness.

For this purpose, a separate chamber, without a chimney, and through which a current of air may be directed when necessary, is chosen.

To a hundred pounds of silk extended on poles at the height of seven or eight feet, about a pound and half, or two pounds of sulphur are taken. This sulphur being grossly powdered, is put into an earthen vessel or iron pot in the bottom of which is a small quantity of ashes, and set fire to in several places. The chamber is then shut close, to prevent the
fumes

fumes from escaping. The next day the windows are opened, to let out the fumes and dry the silk: but in winter, as soon as the sulphureous smell is gone, the windows are again shut, and to dry the silk, chafing dishes with live coals are placed in the room.

This operation not only gives the silk a great whiteness, but at the same time a kind of tremulous elasticity, or rustling, perceptible on pressing it between the fingers.

As this rustling of silk is attended with a certain stiffness, that which is intended for making watered silks should not be sulphurated, because it would offer too great resistance to the impressions of the calender, under which stuffs are passed to water them.

Neither can sulphuration be employed for silks designed for felt (*bonneterie*) as it would corrode the iron and steel of the tools used in manufacturing it, and produce rust.

Silk which has been sulphurated takes most colours badly, and if it be necessary to dye it, it must first be deprived of its sulphur, by repeated soaking and shaking over in hot water (vide page 135).

When silk is sulphurated, if it be not blue enough for the shade desired, it must be azured
a second

a second time in clear water without soap, and after that, again sulphurated.

The properties of sulphurated silk are owing to the sulphureous acid combined with it, the existence of which is rendered sensible by means of sulphuric acid, for this immediately disengages from it sulphureous vapours. The sulphuration of woollen cloths is performed in nearly the same manner as that of silk: but it must be remarked, that if the operation be not managed with caution, and if the combustion of the sulphur be carried on with too great rapidity, sulphuric acid will be formed, which, collected in drops, will corrode the cloth; an inconvenience not easily to be avoided.

C H A P. XI.

Of Arsenic.

ARSENIC is a metallic oxyd found in commerce in white lumps, powdery at the surface, and internally crystalline, transparent, and as it were vitrified. Exposed to the air it soon becomes opaque, and is gradually
reduced

reduced to a kind of flour; which may occasion the most fatal accidents, if mistaken for other substances; but is easy to be distinguished by throwing a little of it on burning coals, when it immediately rises in a thick smoke, and gives out a strong smell of garlic. If the proportion of oxygen be increased by means of nitric acid, this oxyd assumes the characters of a peculiar acid, termed the arsenical: if, on the contrary, it be deprived of its oxygen, by being urged in the fire with oily substances, it sublimes, and takes the form of a semi-metal.

Oxyd of arsenic dissolves in fifteen or twenty parts of boiling water, but it requires a much larger quantity of cold water. Formerly arsenic was much used in many dyes, and particularly for printed linens: but the inutility of this poisonous substance being now acknowledged, it is used in very few processes, and even in these it appears to be useless. The following preparation, however, may be excepted.

Fixed alkali has the property of combining with arsenic, as Macquer has shewn^a. To effect this combination, oxyd of arsenic in powder must be thrown into warm water containing a considerable proportion of alkali,

^a Mem. de l'Acad. 1746.

till no more will dissolve. The liquor becomes of a dark brown colour, and acquires the consistence of glue. This mixture, on cooling, becomes hard and brittle; but it attracts the moisture of the air, and again becomes viscous. Mr. Vogler has observed, that it was a very proper mordant for linen and cotton to be dyed with madder ^b. For preparing it he employed a solution of common pot-ash: others use pot-ash in its pure or caustic state ^c.

Orpiment is a compound of oxyd of arsenic with sulphur, found native, and imitable by art. The more sulphur it contains, the more its colour inclines to red. It is also known by the names of yellow or red arsenic, realgar, sandarach, &c. According to a late analysis of Mr. Westrumb ^d, one hundred parts of orpiment contain twenty parts of sulphur, seventy-nine of oxyd of arsenic, and one of iron. This substance is employed in some processes of dyeing, particularly in certain indigo vats.

^b Ann. de Chym. tom. iv. p. 122.

^c Sieffert's Versuche mit einheimischen Farbematerien.

^d Kleine Phys. chem. Abhandlungen.

C H A P. XII.

Of Water.

TH E qualities of different waters are essential objects to the dyer: but it is perhaps of less importance to point out the injurious effects they are capable of producing, than to destroy the prejudices to which they frequently give rise.

It would be superfluous to say, that water employed in dyeing should not be muddy, nor contain putrid substances; and that waters so loaded with heterogeneous principles as to be termed mineral, which are easily distinguishable by the taste, ought not to be used. With these exceptions, water acts on colouring matter, principally by means of the salts with earthy bases it contains. These salts are nitrat of lime and of magnesia, muriat of lime and of magnesia, sulphat of lime, and carbonat of lime and of magnesia.

All these salts with earthy bases oppose the solution of the colouring particles, cause various kinds of them to precipitate, in consequence of their combining with the earth they contain, and render their colour deeper and frequently more dull.

The carbonats of lime and of magnesia have also the inconvenience of being precipitated by boiling, which drives off the excess of carbonic acid that held them in solution, so that these earths adhere to the stuff to be dyed, make it dirty, and prevent the colouring matter from penetrating it.

It is of consequence, therefore, to distinguish the several kinds of water called hard, that they may be avoided in most operations of dyeing. Chemists are furnished with means not only of detecting the different principles contained in water, but even of ascertaining the quantity of each with precision: but the processes necessary for these analyses frequently require profound skill, and a readiness of practice, which those who are employed in dyeing cannot be presumed to possess. Happily an easy and common experiment is sufficient, to shew whether water contains such a quantity of these salts as may be injurious; the solution of soap.

All salts with earthy bases decompose soap by a double affinity: their earth combines with the oil of the soap, whilst their acid unites with its alkali; and this combination of oil and earth forms an earthy soap, which, being insoluble in water, produces the curdling observed on such occasions ^a.

^a Mem. de l'Acad. 1780.

If then, a water be clear, not stagnant, void of sensible flavour, and dissolve soap well, it may be deemed proper for dyeing; and all waters possessed of these qualities are equally proper.

But as it is not always in our power to choose our water, means of correcting bad waters, at least those which are so to a certain degree, have been sought; particularly for the purpose of dyeing delicate colours. For this end, water in which bran has been made to grow sour, generally known by the name of sour water, or *sours*, is commonly employed.

For preparing the sour water, twenty-four bushels of bran are put into a tub or vat that will contain about ten hogsheads: a large boiler is filled with water, which, when just ready to boil, is poured into the vat: the acid fermentation soon commences, and in twenty-four hours the liquor is fit for use.

I conceive, that the sour water acts by decomposing the carbonat of lime and magnesia, from which its acid, being more powerful, disengages the carbonic acid: thus the earthy sediment, which I have said is occasioned by boiling, is prevented from taking place.

Mucilaginous plants are boiled with water to correct it also. The mucilage coagulates,
and

and carrying with it the earths that separate by ebullition, as well as those which might happen to be simply mixed with the water and render it turbid, forms a scum which is taken off.

Salts with earthy bases, which are in general prejudicial in dyeing, may be in some cases useful, and serve to modify tints. Thus a water of this kind would give a crimson hue to the colour of cochineal.

As the water of a river may contain a greater or less quantity of salts with earthy bases, according as its bed is greater or less, it happens sometimes, that the same shade is only obtained at certain times, though exactly the same process is followed; or that, to obtain the same result, certain variations must be made in the process, according to the state of the river.

Water which decomposes common soap, and forms calcareous soap, is improper for bleaching; not only on account of the loss of soap, which is decomposed in waste, but more especially because the calcareous soap, which is insoluble in water, adheres to the cloth, gives it a greasy feel, and even grows yellow in time, and shakes off in little flakes.

E R R A T A.

Page 21, line 9, *after* referred, *insert* the.

— 142, — 12, *for* Beaumé, *read* Baumé.

— 178, — 9 from bottom, *for* independant, *read* independent.

— 240, — 3, *for* Dambournay, *read* d'Ambourney.

— 295, — 10 from bottom, *for* felt, *read* stocking web.

